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International Marine Engineering

MAY, 1912

The French Bucket Dredger Bassure de Baas

The bucket dredger *Bassure de Baas,* illustrated on this page, has been built this year by the Société des Ateliers et Chantiers de France, Dunkerque, for the French administration of Ponts et Chaussées at Boulogne, and to plans approved by Monsieur Delmotte, engineer to the Ponts et Chaussées, whose extensive knowledge of dredging operations and of the special requirements of that port were invaluable to the builders in preparing the plans. She is one of the most powerful dredgers built for this department, and has been specially designed for dredging in very hard grounds. To this end every part of her structure has been very strongly built, and ably stronger than those required by the Bureau Veritas for this type of vessel. The riveting of the hull, main framing and bucket ladder has been, where possible, done by hydraulic power.

A strongly-built raised forecastle ties the two sides of the vessel above the ladder well, and carries the blocks supporting the weight of the bucket ladder. The hull is divided into eighteen watertight compartments by means of longitudinal and transverse bulkheads, in order to ensure a good margin of buoyancy in case of collision.

A comfortable accommodation for captain, engineers and

FIG. 1.—FRENCH BUCKET DREDGER BASSURE DE BAAS

special attention has been paid to the withstanding of the enormous shocks met with from time to time. The general dimensions are as follows:

Length over all	206 feet.
Length on waterline	189 feet.
Breadth, molded	38 feet.
Depth, molded	15 feet.
Speed (loaded with 650 tons of material)	6½ knots.
Output per hour from a depth of 26 feet below the waterline	10,000 cubic feet.
Maximum depth of dredging (with the bucket-ladder at an angle of 45 degrees).	60 feet.

The center portion of the vessel is a hopper of 10,000 cubic feet capacity, the doors of which are opened and closed by means of a powerful steam winch situated amidships. An arrangement is fitted which permits of the doors being opened either all at once or singly, should it be necessary. Shoots are arranged, fitted with big gate valves, enabling the vessel to discharge the dredged matter into her own hoppers or into hopper barges at either side. These gate valves are built of steel and thickly armored with elm, each having a special steam winch for its opening and closing. The hull has been built of Siemens-Martin steel, the scantlings being considercrew is provided under deck, and a luxurious office is provided for the superintendent and placed abaft the engine room. Ventilation and light are abundantly supplied, and a continuous service at sea is easily possible. A complete electric and oil-light installation is fitted throughout, four arc lights being fitted on deck to permit of working at night. A well-fitted smithy and workshop is placed under the forecastle head. The storerooms are large, as necessitated on this type of vessel.

The vessel is propelled by twin-screws, driven by two compound, surface-condensing engines. These engines are also used singly for driving the dredging apparatus, being connected and disconnected by means of direct clutches. Their principal dimensions are as follows:

High-pressure cylinder	16 inches.
Low-pressure cylinder	32 inches.
Stroke	24 inches.
Revolutions per minute	120
Total indicated horsepower	750

Steam is supplied from two Scotch boilers of 14 feet diameter and 11 feet length, working at a pressure of 130 pounds per square inch. A "Field" type donkey boiler supplies the auxiliary machinery, heating, dynamo, etc., while in port.

The coal bunkers and feed-water tanks are large enough to permit of 70 hours' continuous steaming at full speed.

The auxiliary engines for maneuvering the vessel consist of powerful twin-cylinder steam winches placed at the bow and stern for regulating the mooring chains during dredging operations and also serving as windlasses. The forward winch, which extends the full width of the vessel, develops 110 indicated horsepower, and comprises six barrels and 2 gypsy-wheels. The after winch is somewhat smaller, developing 50 indicated horsepower, but possesses the same complement of barrels and gypsy-wheels. It is also arranged to gear up with the chain of buckets so as to enable it to be turned in time of repairs.

A steam crane, lifting 8 tons at a radius of 29 feet, is placed on the forecastle head to facilitate the repairs to the chain of

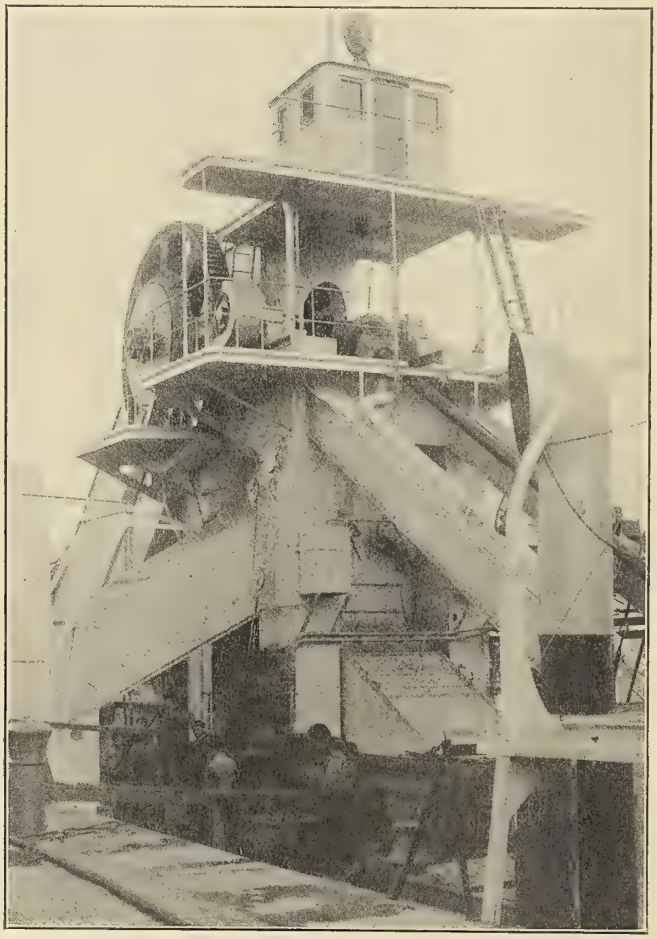


FIG. 2.—VIEW SHOWING FRICTION CLUTCH ON BUCKET DRIVE

buckets, and also for the removal of the heavy stones occasionally brought up, which, if allowed to fall into the hoppers, would probably go right through the bottom. It was not long ago that a piece of rock weighing 6 tons was brought up by a dredger in Boulogne harbor, and stones of about 1 ton are a common occurrence when dredging in the hard ground.

The hoisting and lowering gear for the bucket ladder consists of heavy four-fold blocks, rove with a flexible steel wire rope of 5½ inches circumference. This rope is wound round a drum driven by a double worm gear, actuated by a special winch situated under the deck. This winch is twin-cylinder, and develops 190 indicated horsepower. It is maneuvered from the deck, under the control of the chief dredger. By this means the bucket ladder can be raised or lowered at will and at a speed of 5 feet 3 inches per minute.

The dredging apparatus, as above mentioned, is driven by one main engine at a time, the power being transmitted by very heavy cast steel gear wheels. A transmission room is placed between the stokehold and the engine room, where there are two different multiplications of gear, used according to the nature of the ground dredged. From the transmission room the power is transmitted by an inclined shaft actuating by more heavy cast steel pinions and bevel wheels the tumbler prism driving the chain of buckets.

A great feature of the drive is an enormous friction clutch on the upper tumbler prism shaft, which can be regulated so as to slip whenever the buckets come into contact with something abnormally resistant, thus diminishing the heavy shocks due to encountering big pieces of rock, etc. This clutch, which is the invention of Mr. Boyd, managing director of the builder's firm, is clearly shown in Fig. 2, a most useful point being that it can be regulated with the machinery in motion, thus permitting the regulation to be made to a nicety.

The buckets are formed of cast steel backs with hard steel plate bodies. These are surmounted with sharpened lips of special quality steel. All the riveting is hydraulic. Each bucket is of 12.5 cubic feet capacity, and there are forty in the entire chain. The buckets themselves weigh about 1½ tons each, and the forged steel links connecting them weigh ½ ton a pair. The chain of buckets is guided along the bucket ladder on cast steel rollers, of which there are fourteen. The tumbler prisms are of cast steel, easily accessible and automatically lubricated by grease under pressure. After passing the upper tumbler prism the chain of buckets passes over a guide wheel, which prevents the slack in the chain from touching the structure of the main framing when dredging in deep water.

A large double-acting pump, placed in the engine room, ejects water onto the shoots in order to facilitate the sliding of sticky materials, such as clay, etc.

The stern compartments occupied by the machinery are covered by a spacious deckhouse, in which is fitted auxiliary machinery, such as pumps, ash-hoist, steering gear, etc. The donkey boiler occupies the forward portion of this deckhouse.

The dredger, fully equipped, is completed by two lifeboats and a heavy boat, put overboard by two derricks aft, for the placing of the anchors and mooring chains. On the top of the main framing is installed a navigating bridge and a house containing steering wheel, telegraph, chart table, etc. On the top of this house is placed the standard compass.

During trials, and during the six months in which this dredger has been in service, the results have been well in excess of those demanded by the owner's specification. As much as 14,500 cubic feet has been discharged in one hour when dredging in the clay-mud, and 13,000 cubic feet has been about the average. When dredging in the rocky and stony ground naturally no average can be taken, but here also the vessel has given every satisfaction.

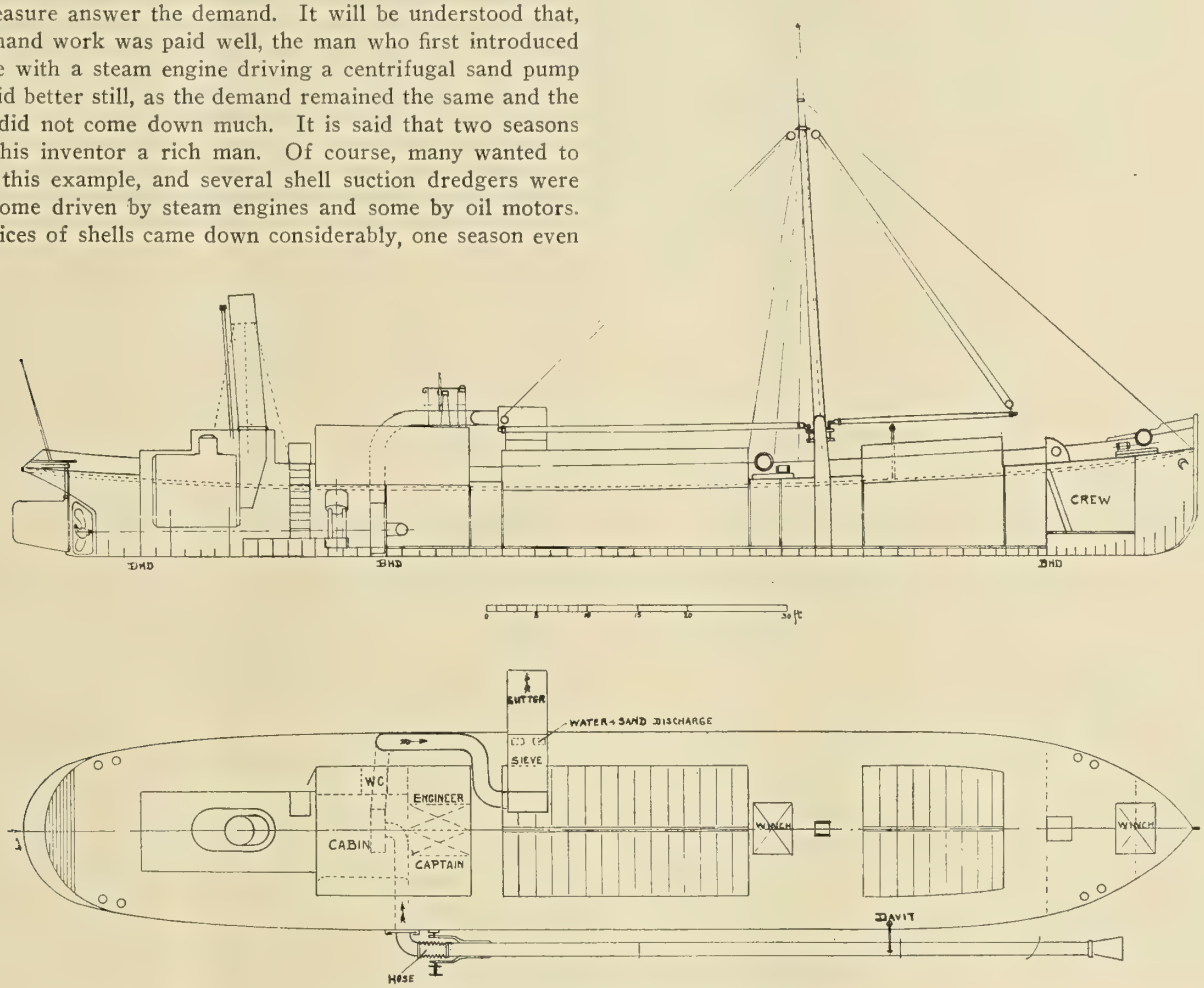
This firm built at the same time a similar dredger of very slightly smaller dimensions for the port of Dunkerque. In this case the hopper doors were actuated by hydraulic power, but otherwise the designs were essentially the same.

Lloyd's Register of Shipping reports that excluding warships there were 545 vessels of 1,686,898 tons gross under construction in the United Kingdom at the close of the quarter ended March 31. The tonnage now under construction is about 168,000 tons more than that which was in hand at the end of the last quarter, and exceeds by 312,000 tons the tonnage building in March, 1911. The present figures are the highest ever recorded in the society's quarterly returns. The total number of warships under construction in the United Kingdom for the British Admiralty is 54, of 319,740 tons displacement. In addition there are seven warships building for foreign governments of an aggregate displacement of 109,700 tons. The condition of shipbuilding in the United Kingdom is therefore much better than ever before in the history of the industry.

Shell Suction Dredger Used in the Dutch Shell Lime Industry

BY F. MULLER VAN BRAKEL

Much of the lime used in Holland is shell lime, produced from the shells that are dug up at the sea coasts. Some twenty years ago this was done exclusively by hand, by means of iron-hooped bags attached to long poles, handled by a man standing on a barge. The total weekly output was necessarily very small; it was well paid, however, the price being about $4 (16s. 8d.) per 100 cubic feet, as the supply did not in any measure answer the demand. It will be understood that, if the hand work was paid well, the man who first introduced a barge with a steam engine driving a centrifugal sand pump was paid better still, as the demand remained the same and the prices did not come down much. It is said that two seasons made this inventor a rich man. Of course, many wanted to follow this example, and several shell suction dredgers were built, some driven by steam engines and some by oil motors. The prices of shells came down considerably, one season even



ELEVATION AND PLAN OF DUTCH SHELL SUCTION DREDGER

to 70 cents (2s. 11d.) per 100 cubic feet. Since then, however, the market recovered somewhat.

One of the latest of these shell dredgers was built in 1908 by Messrs. E. J. Smit & Son, of Hoogezand, Holland, to the order of Messrs. G. Doeksen & Sons, of Terschelling. The ship is named *Willem Barendsz,* after the famous Dutch Arctic explorer, who in 1696 tried to force the Northeast Passage, but, after losing his ship, was forced to pass the winter on Nova Zembla, and died in an open rowboat during the return voyage. The principal dimensions of the *Willem Barendsz* are:

Length between perpendiculars.....	108 feet.
Beam	20 feet.
Depth	7 feet 3 inches.

The hull is built entirely of steel to the rules of the German Lloyd's under special survey. The engine room is aft; the propeller shaft passing under the boiler as the engine and pump are placed close together towards the center of the ship. The accommodation of the staff is in a roomy deck house on the deck near the engine room; the crew's quarters are forward under the deck. Between the engine room and crew's quarters all space is taken up by the hold, which may be filled with shells should no lighters be obtainable, and which gives opportunity to use the ship as a freight steamer during winter time. Usually, however, the shell is delivered into lighters and the hold is used as a coal bunker and workshop. The steering wheel and compasses are on top of the deckhouse, giving a free outlook over sea, which is necessary when navigating on the shoals near the Dutch coast and between the many islands.

A strong pole mast, 46 feet from the deck, with two derricks, is fitted between the two hatches, with a strong steam winch for handling the shell sieve, suction tube or cargo, or for coaling the ship. A heavy steam anchor winch is fitted forward, with a special head for hoisting the suction tube.

Propelling Machinery

The engine and boiler are built to the requirements of the German Lloyds. The 7-foot boiler has a heating surface of 430 square feet and produces steam at a pressure of 160 pounds. The engine is a diagonal one-crank compound engine; cylinders, 9 inches and 16 inches by a 12-inch stroke, which at 200 revolutions develops 110 indicated horsepower.

Air, circulating, feed and bilge pumps are driven from the low-pressure crossheads, and placed on the side where the condenser is attached to the ship's side. An independent steam pump is fitted for boiler feeding and auxiliary purposes. All sea valves are placed on the starboard side, as the water and sand delivery is on the port side. The crankshaft has a coupling flange at each end; the forward one connecting to the pump, the after one to the screw shaft, which bears a four-bladed propeller of 4 feet 3 inches diameter and 5 feet 9 inches pitch.

Dredging Apparatus

The general arrangement of the pumping installation is rather like that of an ordinary suction dredger.* In determining the principal dimensions of pump and suction tube, however, and when fixing the usual number of revolutions, the difference between sand or mud and shells should be taken in account. Experience is here, as in all other cases of engineering, of the first importance.

Pump

The pump is of the ordinary sand-pump type as generally constructed in Holland and Germany. The inner circumference of the casing follows closely the circle described by the impeller blade tips, and only about one-third the circumference deviates from that circle to give access into the delivery tube. There is thus a marked difference between this pump and the ordinary water pump, whose inner form follows a spiral line all around the circumference. It may be mentioned here that the Polson Iron Works, Toronto, and the Nagel & Kaemp Company, Hamburg, Germany, have recently constructed successful sand pumps of the spiral form.

The three Bessemer steel blades of the impeller are slightly curved backwards and attached to the heavy wrought steel impeller arm by screw bolts. As the wear and tear caused by the continual rapid passage of water, sand and shells is tremendous, the pump should be easy to overhaul and fitted out with wearing plates inside, which may be readily renewed. A water chamber is cast onto the stuffing-box, into which water is forced by an independent steam pump or by a branch from the circulating pump delivery. This causes a slow, continual flow of water from the outside, along the shaft, into the inside of the pump, thus preventing any sand getting in between stuffing-box and shaft.

Tubes

The suction tube is attached by a short leather hose, strengthened by a steel mail to a cast iron bend which communicates with the pump tube inside the ship. This bend, as well as the end of the suction tube, can be lowered and raised by appropriate hoisting tackle, and the whole tube with bend and all can be hoisted and stowed on deck when the ship is to sail into harbor.

The delivery tube passes from the pump through the deck-stringer, and leads by way of a sectioned tube to the shell sieve.

Sieve

This sieve rests on rollers which are fitted underneath on the bulwark and on the hatch coaming, and thus may be rolled all along the hatch when the dredger is filling its own hold. The sieve consists of an open rectangular box, in which the sieve plate (5/16-inch steel plate with holes punched close together) is fitted in a horizontal position on three steel bars. The water and sand pass through the sieve plate to a square tube which discharges overboard near or at the waterline. The shells are waterborne while on the sieve, and thus easily shoveled off by one or two men to the inside when loading the ship's hold, or to the outside through a gutter leading to the hold of the other vessel.

Some shell dredgers have a rotating shell sieve of cylindrical form, which is driven by a small steam engine. Though using a great quantity of steam these sieves are capable of dealing with huge quantities of shells and even of assorting them in two sizes and charging two vessels at the same time with different sizes of shells. This, however, is only possible when the suction tube is fitted in the middle line of the ship.

Management

Proper design and reliable construction are the first steps necessary to get a successful shell dredger, but an experienced skipper, who knows where to find shells and how to regulate the number of revolutions of the pump that it may be most efficient, is no less important. It is a common observation on shell dredgers that for a long time only sand and water are brought up, till all at once at a certain number of revolutions the shells appear. The skipper therefore has his place near the sieve, and observing the delivery of the pump, regulates the number of revolutions accordingly by means of a hand-wheel which is connected to the steam throttle valve.

The *Willem Barendsz* has proved to be a very successful dredger, and has many times beaten other dredgers of greater power. As pointed out above the efficient design and construction are not the only causes of this. A great part of the success is due to the skillful and tenacious handling by the crew, who every year keep up dredging till the December storms prevent other vessels coming alongside to take in shells.

The biggest delivery for one day of fifteen hours has been 4,300 cubic feet; a mean delivery of 1,500 to 2,000 cubic feet in fourteen hours is more usual, working from 175 revolutions, when the impeller blades are new, to about 210 revolutions when they are worn away. The steam pressure when dredging is usually 125 to 135 pounds. The crew consists of a skipper, engineer, mate, fireman, two deck hands and cook.

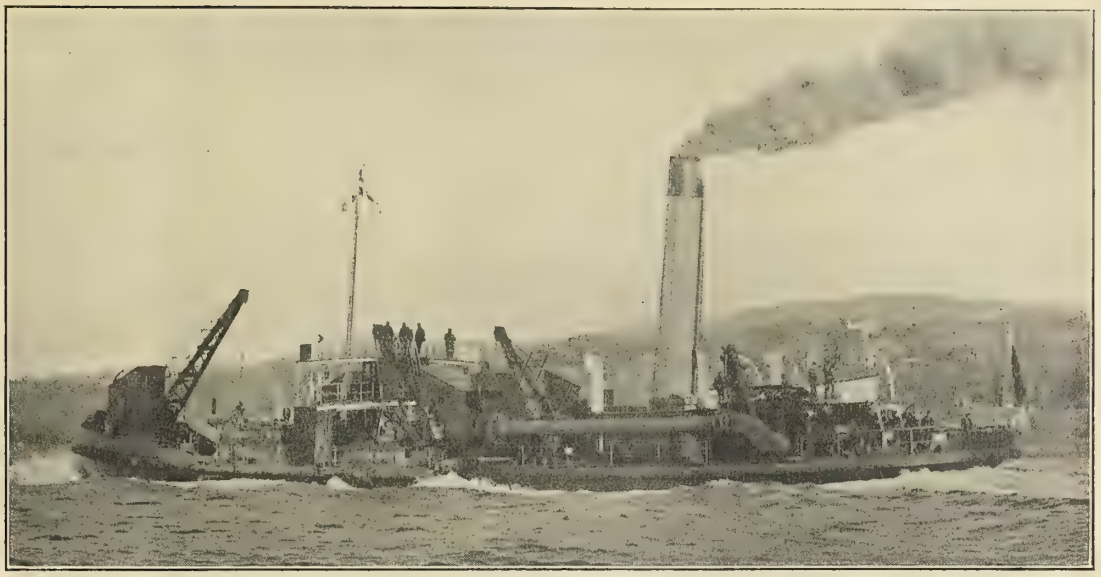
* For a very complete and fully illustrated article on sand pumps and gear, see *Zeitschrift des Vereines Deutscher Ingenieure*, 1909, page 969, and 1910, page 657.

Dredger Rhyl for the London and North Western Railway Company

Messrs. Ferguson Bros., of Port Glasgow, have built a powerful twin-screw combined suction and grab dredger named the *Rhyl* for the London & North Western Railway Company's service at Garston, on the Mersey. The vessel is classed 100 A 1 at Lloyd's, and has been constructed to the specification and under the direction of Commander G. E. Holland, C. I. E., D. S. O., marine and dock superintendent for the company. The four powerful grab cranes are arranged at each corner of the hopper, one of the forward cranes having an extended jib to reach over the bow for dredging in confined spaces.

The machinery consists of twin-screw, triple-expansion propelling engines with a full set of modern auxiliary machinery, comprising one set of Weir's pumps, a feed heater filter, duplex, ballast and separate air and centrifugal circulating pumps. Electric light is fitted throughout. The sand pump is arranged in a separate engine room, and is driven by a set of compound marine type engines, the suction is fitted under the waterline, and has a slide for raising and housing the pipe inboard. This arrangement has some special features which are free from the complications usually found in this type of fitting. Steam is supplied by two double-ended boilers, the working pressure being 160 pounds per square inch.

This is the fourth vessel built for the London & North Western Railway during the last four years by Messrs. Ferguson Bros.



SUCTION AND GRAB DREDGER RHYL

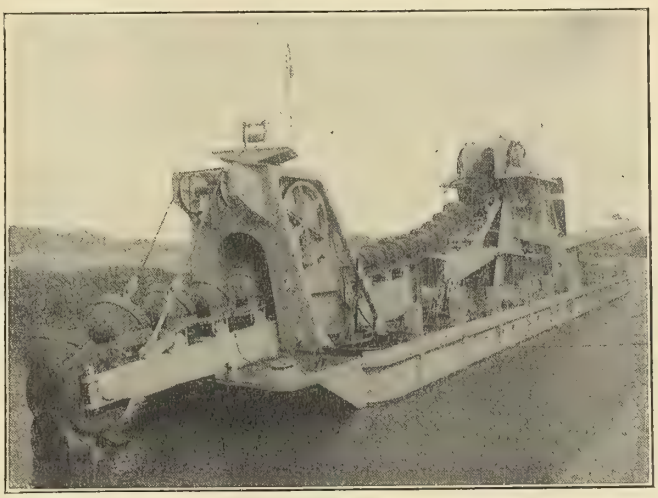
Rotterdam Dredges

Several interesting dredgers of both the bucket and the suction types have been built recently by the Establissement Fijenoord, Rotterdam, Netherlands. The latest of these are of the following dimensions:

Name	Maashaven.	Sliedrecht V.	Europa and Amerika.
Type	Suction-dredger.	Suction-dredger.	Bucket-dredger.
Owners	G. A. van Hattem, Dordrecht.	L. Volker, Sliedrecht.	J. P. Heyblom, Rotterdam.
Length	124 feet	144 feet	148 feet
Breadth	22 feet	31 feet	25 feet
Beam	10 feet	13 feet	11 feet 4 inches
Draft	5 feet 9 inches	6 feet 5 inches	5 feet 7 inches
Engines	Sand pumps 300 indicated horse-power. Water pumps 150 indicated horse-power.	Sand pumps 700 indicated horse-power. Water pumps 200 indicated horse-power.	200 indicated horse-power.

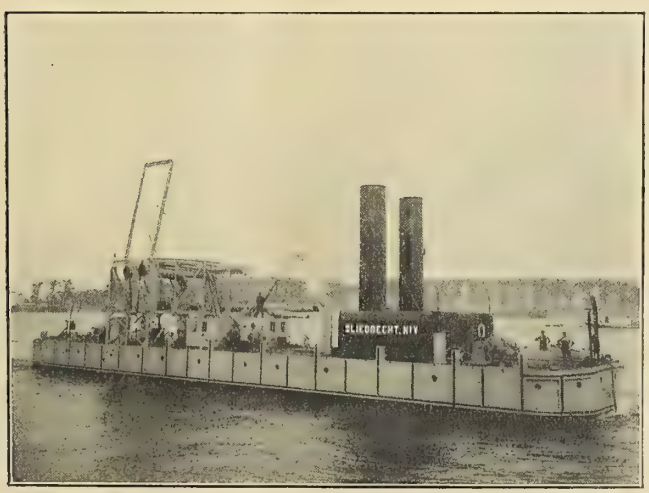
The bucket dredgers deliver the spoil into hopper barges placed alongside. The shoots are movable for this purpose. The dredger can work to a depth of 40 feet with the ladder in its ordinary position, while by altering the upper bearing of this to a special support the depth reached can be extended to 60 feet. The bucket capacity is 21 cubic feet; speed, 12-18 buckets per minute.

The suction dredgers are designed for unloading barges alongside, and delivering the sand or heavy clay at a long distance through a piping arrangement (the *Sliedrecht V.* delivers up to a distance of 6,500 feet). The *Europa* and



EUROPA

Amerika are constantly at work in the Suez Canal, the *Maashaven* at the harbor works in North Germany, and *Sliedrecht V.* mostly for the Municipal Works of Rotterdam.



SLIEDRECHT NO. V

The Bureau of Navigation reports 1,051 sailing, steam and unrigged vessels of 151,341 gross tons built in the United States and officially numbered during the nine months ended March 31. Of these, 21 aggregating 20,258 gross tons and 18 aggregating 52,895 gross tons were steel steamships built on the Atlantic and Gulf coasts and on the Great Lakes, respectively. During the corresponding nine months ended March 31, 1911, a total of 987 vessels of 228,677 gross tons were built in the United States. The total built during the month of March this year is 130 vessels of 18,829 gross tons.

Notes on Hydraulic Dredge Design

BY M. G. KINDLUND*

It is the intention of this article to discuss briefly a few of the problems that confront the engineer in the design of hydraulic dredging plants. Only those dredges discharging through long pipe lines will be considered at this time, as a greater diversity of experiences and of opinions seems to exist in regard to this type of machine than to those discharging directly into hoppers or barges.

Theoretical considerations are usually not given much thought in ordinary dredging operations, and unless the contract in hand involves a large amount of money and extends over a considerable length of time, it is of perhaps small consequence whether the conditions are met by a suitable design or not. It is usual to employ the same plant on many contracts, and it is obviously an advantage to suit average conditions that experience teaches us are most liable to be encountered. However, there are many times when a careful study might profitably be made of special conditions that can only be successfully met by alterations in existing designs or by building an entirely new plant. The preliminary expense and delay will be amply justified by results, as has been demonstrated many times. The greatest efficiency is desirable in a plant working so continuously as does a dredge, and the utmost care exercised to guard against breakdowns that involve loss of time. To every dredging contractor the pertinence of the ancient proverb, "Time is money," has been brought home more than once.

Five considerations have been selected from among a number, which will be taken up in the succeeding paragraphs:

1. The selection of the proper size of pipe.
2. Determining the power required.
3. Design of the pump.
4. Auxiliary deck machinery.
5. Hull.

Proper Size of Pipe

Hydraulic dredging is a process whereby solid material, heavier than water, is transported through pipes by virtue of the velocity of a current of water. The prime requisite, then, is velocity. By reference to the following table the effect of increasing the size of pipe on the quantity of water pumped with the same expenditure of power is shown:

Diameter of Pipe in Inches	Quantity of Water	Percent Increase
16	100	..
18	122	22
20	145	19
22	170	17
24	195	15
27	238	22
30	283	19

It is seen that, theoretically, by increasing the diameter of pipe a single size the efficiency of the operation may be increased from 15 to 22 percent. Here are two conditions that the designer has before him: First, the smaller the diameter of pipe he uses the higher the velocity and the greater the percentage of solids in the mixture transported. Secondly, the larger the diameter the greater the volume of mixture that will be carried for a given expenditure of power. He must find the proper size of pipe that will ensure a sufficient velocity to carry the material in suspension and at the same time give the maximum discharge obtainable.

Light material, silt and fine sand, are easily carried in suspension by the water. For these a greater diameter with lower velocity may be employed than for coarse sands and gravel. A limit to the velocity of discharge is reached when the friction head begins to increase at too rapid a rate. This critical velocity, as it may be termed, for sizes in the neighborhood of 20 inches occurs at about 12 feet per second. Not only does the friction become excessive beyond this point, but if sand is being pumped the abrasive action on the internal surface of the pipe becomes too severe. Thus a practical limit is set for sand dredging, which it is not wise to exceed. A gain in proportion of solids transported may be offset by the necessity of more frequent renewals of discharge pipe. The accompanying set of curves demonstrates quite clearly the rapidity with which the power increases with small increases of velocity. These curves were prepared from data obtained during a series of tests of a 24-inch dredging plant pumping water through varying lengths of pontoon and land pipes. The friction factors are much in excess of those commonly used for cast iron pipe, as might be expected, and are higher for pontoon pipes connected by rubber sleeves than for land pipe, the ends of which are telescoped one into the other.

For those dredging contracts where the greater part of the pipe rests on the fill, or is carried across intervening ground, instead of being supported by floating pontoon pipes, the labor involved in handling the large sizes, *i. e.*, changing from one position to another, turning the pipe around, telescoping and packing the ends, etc., sometimes prohibits the use of the most economical size. Under certain conditions the consequent loss of time and extra labor may counteract the increased efficiency.

Thus practical as well as theoretical limits are set for both minimum and maximum sizes of discharges, but it is manifest that the selection of the proper intermediate diameter is a matter of serious consequence. On an extensive piece of work it may mean either success or failure.

The results of dredging contracts with which the writer is familiar, extending over long periods of time, show it to be true that the effect of using too small a pipe is to diminish the output in cubic yards in a degree commensurate with that obtaining for water. As noted above this may vary between 15 and 22 percent. It has been demonstrated, for instance, that for the same expenditure of power 20 percent more material can be transported through 27-inch pipe than through 24-inch pipe. Practice and theory agree, then, that the most efficient size pipe to use for any given power is the largest size in which a velocity can be maintained sufficient to carry in suspension the material encountered.

Power Required

Now, turning to the determination of the required power to meet conditions we find the following factors entering in:

(*a*) Diameter of suction and discharge pipe.

(*b*) Kind of pipe, length of each kind and character of end connections.

(*c*) Static head.

(*d*) Design of such details as suction head, stone box, ball joints, non-return valve and bends in hull pipe.

(*e*) Efficiency of pump and of engine, which may vary from 35 to 70 percent.

(*f*) Nature of the material and the proportion of solids to total mixture transported.

The effect of diameter of pipe on the necessary power was taken up in the preceding paragraphs. As regards the kind of pipe used and end connections of same, the friction coefficients for floating pontoon pipe are in excess of those for land pipe by amounts varying from 35 to 45 percent, depending on the

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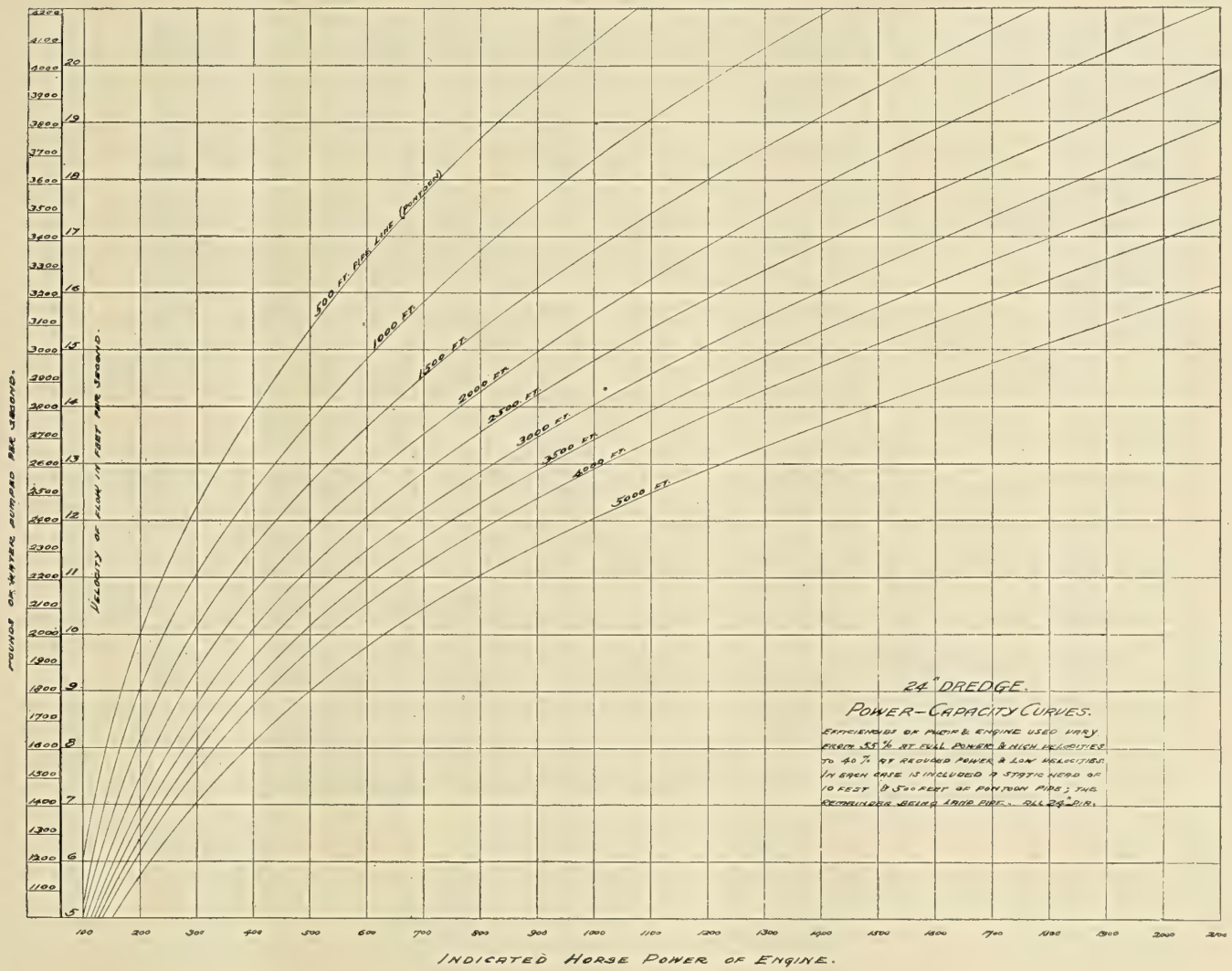
velocity of current. For instance, at a velocity of 10 feet per second the friction head per thousand feet of pontoon pipe is 17 feet, while for land pipe it is 12.5 feet. Similarly, the values at 15 feet velocity are, respectively, 38 feet and 26.7 feet. These figures include suction, discharge and velocity heads; but, of course, no lift, and were determined for 24-inch pipe pumping water only. They are well above the friction heads for cast iron pipe, and show the effects of sudden expansion at the rubber connections, of an occasional short bend common in dredging, of the irregularity of flow through pipe lying on uneven ground, and of a few small leaks that it is almost impossible to prevent. Were dredging mixtures carried through pipe of uniform diameter, with long radius bends, smooth joints and no leaks, the price per yard charged by contractors would be considerably lower than obtains at present.


24" DREDGE.
POWER-CAPACITY CURVES.
EFFICIENCIES OF PUMP & ENGINE USED VARY FROM 35% AT FULL POWER & HIGH VELOCITIES TO 40% AT REDUCED POWER & LOW VELOCITIES. IN EACH CASE IS INCLUDED A STATIC HEAD OF 10 FEET. 8,500 FEET OF PONTOON PIPE; THE REMAINDER BEING LAND PIPE. ALL 24" DIA.
500 FT. PIPE LINE (PONTOON)
1000 FT.
1500 FT.
2000 FT.
2500 FT.
3000 FT.
3500 FT.
4000 FT.
5000 FT.
POUNDS OF WATER PUMPED PER SECOND.
VELOCITY IN FEET PER SECOND.
INDICATED HORSE POWER OF ENGINE.

POWER-CAPACITY CURVES FOR A 24-INCH DREDGE

The indicated horsepower of the engine is given by $I.\ H.\ P. = W \times H \times k$, where W is weight of mixture transported per minute, H is total head in feet, k is a coefficient representing combined efficiencies of pump and engine.

The total energy imparted to the fluid, whether it be water or a mixture of sand and water, is expended outside the pump itself, in overcoming entrance head, friction in pipes, actual lift and in creating velocity. All this is included in the term "head."

The most obscure portion of the calculation for horsepower is the determination of velocity of flow necessary to transport a given percentage of solid matter, and also the increased friction head due to this mixture. We know from experiments the power required to pump water through dredging pipe per thousand feet. We know from the results of dredging operations the approximate proportion of solids transported for a given power with varying lengths of pipe line. On long lines the solid material is sometimes not more than 5 percent of the total, even though the mixture has been "saturated" most of the time, as it is, of course, the endeavor of the dredge operators to carry the maximum quantity without clogging.

We find that up to lengths of 1,500 or 2,000 feet the current is not usually saturated; that is, the yardage is not proportional to the length of pipe line, as is the case beyond these lengths. This is due, of course, to the failure of the suction to gather in sufficient material. Either the apparatus designed for loosening the earth and sand or cutting the clay is not effective, or else the suction head is not properly shaped to introduce the material into the pipe. Then, too, there is a limit to the power of the suction, no matter how great the velocity of flow may be, and material outside of its influence cannot be dislodged. A form of scraper head, such as is used quite generally on Government dredges, is well adapted to handle silt and fine sand, and the Frühling type of suction head, with provision for diluting the mixture at will to the proper

consistency for pumping, is admirably suited for light material, particularly in the case of a hopper dredge, where the discharge line is very short.

In the absence of reliable data, derived either from practice or experiment, on the increased friction head resulting from carrying varying proportions of sand, it seems fair to the writer to assume that the head will vary directly as the density of the fluid as long as the velocity is sufficient to carry the solids in suspension. If any readers of this article know this to be an unjust assumption for the sand percentages ordinarily found in practice, say up to 25 percent, the writer would consider it a favor if he were corrected. This assumption does not hold in the case of argillaceous earths, which exert far less frictional resistance to hydraulic transportation, and there are certain unctuous clays which even seem to contribute to the facility of their own removal. Of course, the weight of fluid transported may be easily computed for a given proportion of solids, and so the first two factors in the estimation of horsepower may be obtained. The third factor—efficiency of pump and engine—will be taken up in the following paragraphs:

Design of the Pump

The pump, the so-called "heart" of a suction dredge, is perhaps the most important feature of the plant, for on it depends, in large measure, the efficiency and capacity of the outfit. When sharp sand is encountered the wear on the internal surfaces is so great that the time and labor necessary to renew the worn parts becomes a serious consideration. If liners are used they may be arranged to facilitate renewals, as the maximum wear occurs always in the same parts. High-carbon steel plate liners give perhaps the best service, neglecting manganese steel, but even these will be cut through surprisingly fast. With unlined pumps there have been times when 1,000 hours of dredging have worn a 2½-inch cast iron case entirely through. Manganese steel liners are sometimes used, which, of course, have a much longer life. Recently manganese steel castings have been employed for the entire pump case, the drilling and tapping being accomplished by providing cast iron inserts in the flanges and elsewhere where necessary. The faced portions are ground, and so a practicable pump case is constructed from a steel that resists machining, but resists likewise the abrasion caused by sand and the blows of solid objects.

The writer has seen a plate liner cut through at the line of maximum wear, *i. e.*, at the tip of the runner blades, causing a point of the plate to bend out far enough for the runner to strike it. The plate was torn and curled up like a shaving of wood through an arc of about 90 degrees until the resistance stopped the engine. Is it any wonder that pumping engines on a dredge have to be strongly built, when they may be thus brought to a dead-stop from 200 revolutions per minute through a quarter turn?

High efficiency is something striven for but rarely attained in a dredge pump. Certain fundamental requirements for efficiency are impossible where large, hard objects have to be handled. It is surprising, by the way, to one unfamiliar with hydraulic dredges to learn of the strange and apparently unmanageable objects that pass into the suction and out of the discharge, perhaps half a mile away. Stones about 18 inches square and 24 inches long have made the trip through a 20-inch diameter pipe; likewise pieces of 3-inch pipe, 36 inches long, with fittings at the ends, lengths of chain, big chunks of concrete, pieces of wooden piles, etc., have been picked up on the fill or removed from the pump casing. This indicates the eminent desirability of spaciousness in the pump passages, and this very requirement precludes anything more than a fair efficiency, say 50 percent. The following brief explanation will outline the reasons for this:

The energy imparted to the mixture of water and solids in its passage through the runner or disk is in two forms, potential and kinetic, *i. e.*, pressure and velocity. The pressure is due to the action of the centrifugal force of the rotating mass contained between the vanes, and the velocity approximates to the peripheral speed of the runner. The radial component of this velocity should be as great as possible, and this may be accomplished by tapering the sides of the runner to gain a gradually decreasing section as the distance from the center increases. The object sought is a more nearly uniform radial advance of the column of water. This, of course, is out of the question for a pump whose minimum clear passage should be at or near the center, where any obstruction may be easy of access from the suction manhole. Thus the velocity is almost entirely a "whirling" velocity, and as the water is discharged directly from the runner into a large chamber the kinetic energy is practically all lost. The converting of this energy into pressure, by a throat or expanding passageway leading into a volute, accounts for the relative high efficiencies of centrifugal pumps handling water only.

The only theoretical advantage possible for a dredge pump is the provision of a volute case, where increasing quantities of water issuing from the runner at increasing distances from the point of discharge, in the direction of rotation, may meet water flowing around the casing at nearly uniform speeds. A volute, or modified volute, case is desirable for sand pumps, but the extra efficiency gained is hardly appreciable when the other theoretical advantages are not at our disposal. Extensive tests with dredging pumps participated in by the writer, and the results of which he is familiar with, have demonstrated that there is very little or no gain in efficiency due to the volute form of casing. The same pump was used under identical conditions, pumping water first with a circular case and then a volute, and practically the same efficiency resulted.

The type of runner, likewise, does not very materially affect the efficiency. Either open or closed runners may be designed to give equally good results. The capacity, however, is usually greater with a closed or shrouded runner. The tests above mentioned show this to be true, and those conducted by the Government engineers on the Mississippi River dredges prove it conclusively. A closed runner on the dredge *Epsilon* showed 12 percent more capacity than an open runner on dredge *Zeta*, the pumps in other respects being identical. On the *Zeta*, furthermore, three runners, with 3, 5 and 7 blades, were tested, the efficiency varying but slightly, but the capacities of the 5 and 7-bladed runners were, respectively, 25 percent and 27 percent greater than the one with the three blades.

The outstanding advantage of the closed runner, however, lies in the greatly reduced wear on the internal surfaces of the pump. There is not the continual grinding action of the sand between runner blades and casing, with the necessity of renewals and loss of efficiency due to enlarged clearances; there is no "spilling" over the edges, so to speak, but the mass of water and solids is confined between the faces of the runner. Of course, the disk of the latter is subject to wear, but this is comparatively unimportant. A closed runner, furthermore, may be more easily balanced. In the writer's opinion this type is much to be preferred.

Auxiliary Machinery

The auxiliary machinery required to move a dredge not self-propelled, to raise and lower the ladder supporting suction pipe and cutter, to raise and lower the spuds and to perform other deck operations, is capable of decided improvement on the majority of dredges built in this country. First cost has much to do with the rather crude apparatus often employed, but many times it is due to lack of attention to details. It is left to the last, has to be hastily erected, and made to suit the construction of hull and upper works. Fortunately, greater

care is now being given to this feature of dredge operation than formerly. This is apparent in the more compact arrangement of drums, frictions, etc., and a more rigid connection to a bedplate extending under all bearings; cut steel gears have replaced rough cast iron, clutches and brakes are operated by steam rather than by hand. The results have been manifold; gears are less easily broken, the life of bearings is lengthened, vibration and noise are reduced, less power is required, and a reign of intelligence rather than brute strength on the part of the operator has been inaugurated. There is still room for improvements, and these will come as machines are built to last instead of being put together for specific contracts.

Hull Design

In conclusion, a word may be said about the hull proper. It should be laid out last and designed to suit the machinery, which, it is needless to say, is arranged as compactly as possible. Too often hull construction comes first, and features are introduced that preclude the most desirable placing of machinery. It is, of course, very important to have rigid foundations for the engine, pump and auxiliary machinery, and that the hull generally be strong enough to resist hogging and sagging strains. But this result may be obtained by suitable construction, especially when steel is employed for hull material.

The writer has proposed a composite construction combining some of the advantages of both wood and steel, giving a very rigid structure in a fore-and-aft direction and a space below deck free from massive wood trusses and bulkheads, while preserving the unquestioned advantages of wood planking and decks. A complete steel hull is considerably more expensive than wood, but when kept properly cleaned and painted will outlast two wood hulls, and when its advantages as regards strength, convenience of arrangement, ease of providing rigid foundations for machinery, etc., are considered, it seems to be the better investment.

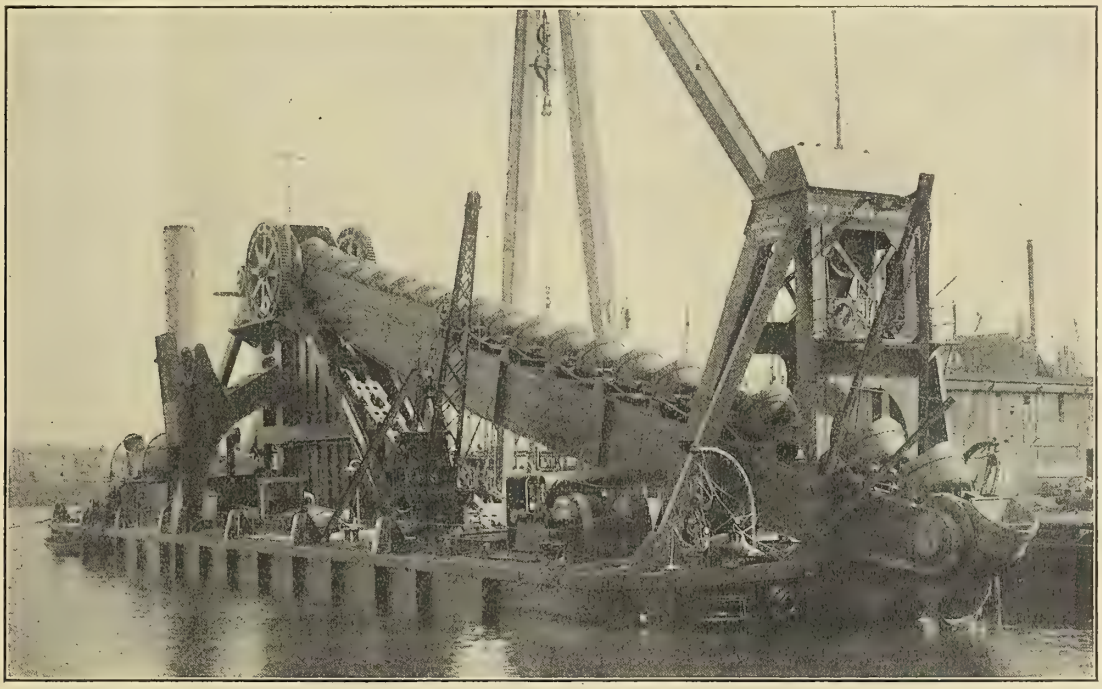
It has been impossible to touch upon a number of points in connection with dredge design that would be of interest, among them being the cutting apparatus and the possibilities of types of pumping engines at present not generally used. Perhaps another opportunity will be offered in these columns for their consideration.

The Largest Bucket Dredger on the Thames

The largest bucket dredger on the Thames was built by Lobnitz & Company, Ltd., of Renfrew, to the designs of the Port of London Authority Engineers. It was named *P. L. A. No. 6,* and has been in operation on the Thames since October last. The dimensions are as follows:

Length	214 feet.
Breadth	40 feet.
Depth	12 feet 6 inches.
Dredging depth	55 feet below water level.
Capacity of buckets	27 cubic feet each.

The dredge is fitted with triple-expansion engines, two large return tubular marine boilers and very powerful mooring and ladder hoist winches.



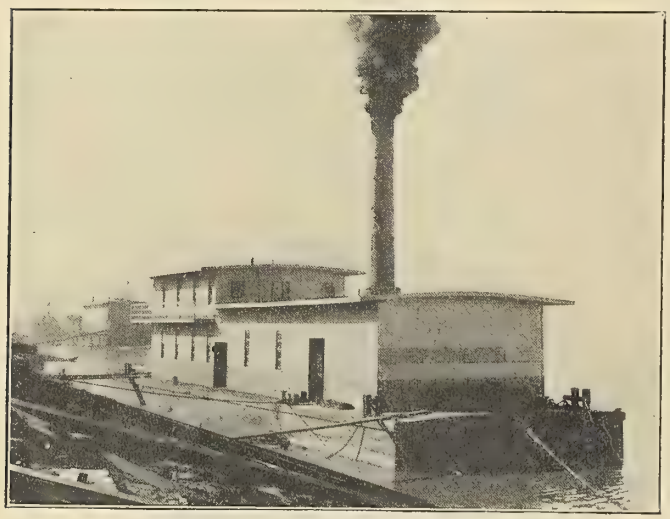
LOBNITZ DREDGER P. L. A. NO. 6

The Dublin Dockyard Company, North Wall, Dublin, are just completing a hopper grab dredger for the Limerick Harbor Commissioners, which has been specially designed by the builders for the owners' particular requirements. The dimensions of the vessel are as follows: Length between perpendiculars, 140 feet; width, 29 feet 6 inches; depth, 12 feet 6 inches, and she is capable of carrying 500 tons of spoil on a draft of 11 feet. She is built of steel to Lloyd's highest class and under their special survey, with additional strengthening for loading on ground. The propelling machinery is placed aft, and consists of a pair of compound condensing engines having cylinders 15 inches and 32 inches diameter by 24 inches stroke. Steam is supplied from a cylindrical return tube boiler 12 feet diameter by 10 feet long, working at 120 pounds pressure. The dredging machinery, consisting of two of Messrs. Priestman's powerful grab dredgers capable of lifting 80 cwts. each from a depth of 45 feet from the vessel's deck, and the forward dredger is designed to work all round so that vessel may cut her own flotation. The specifications for the vessel are very full and call for the most complete equipment.

Test of a Mississippi River Suction Grader

BY THOMAS C. ALLEN

For the purpose of grading the banks of the Mississippi River at certain places the engineers of the Mississippi River Commission make use of a jet of water projected into the bank at high velocity. The operation is similar to the hydraulic mining once so common in some of the gold districts of California. Heavy brass nozzles on the end of very high-pressure hose are used, and the process consists essentially in washing the earth from the banks into the river. The pumping equipment is installed in a houseboat, which is not provided with motive power of its own. This boat is towed along the river as close to the bank as the depth of water will permit. Originally heavy direct-acting pumps were in use for this work, but in grader *No. 1022,* recently built in the Government yards at Memphis under the direction of Capt. Clark S. Smith, Corps of Engineers, U. S. A., an equipment



MISSISSIPPI RIVER COMMISSION GRADER NO. 1022

has been installed by the Allen Engineering Company, Memphis, in which a unit driven by a steam turbine has been employed. This being somewhat of an innovation for this character of work, a brief description will prove of interest.

The hull consists of a barge 110 feet long, 30 feet wide and 6 feet in depth of side. The deck plan is a rectangle. In fact, except for a little sweep upwards at the bow and considerably less at the stern the entire hull has the form of a parallelopipedon. A deckhouse, set back 14 feet from the bow, measures 86 feet in length and 23 feet in width. A second-story at the forward end furnishes living quarters for the crew, and is provided with a balcony on three sides.

The machinery equipment consists in the main of a battery of three boilers, 40 inches in diameter and 26 feet long; one 210-horsepower, two-stage Terry steam turbine, and a four-stage, 8-inch Alberger turbine pump. The steam turbine, with 180 pounds working pressure and 26 inches vacuum, operates at 1,800 revolutions per minute, and is direct connected to the pump, which is mounted on the same base. The pump has a rated capacity of 1,200 gallons per minute against a total head of 480 feet, this including both suction and friction.

The auxiliary machinery includes one surface condenser of the water-works type, containing 470 square feet of cooling surface, supplied by the Wheeler Condenser & Engineering Company, a direct-connected horizontal wet vacuum pump, 6 by 8 by 10 inches; a Cameron feed pump, and a Sims closed type feed-water heater. The latter utilizes the exhaust from the two auxiliaries in heating feed-water for the boiler. The suction water from the river to the pump is the cooling water for the condenser.

This steam turbine is of the multiple-pressure stage type. In the high-pressure stage the steam is expanded from the live pressure down to approximately atmospheric pressure, and the energy is absorbed by a single wheel. In the second or low pressure stage the steam is expanded from the exhaust pressure of the first stage down to the vacuum as carried in the condenser, the energy being absorbed by two wheels in this stage. Each of these low-pressure wheels has its own system of jets and reversing chambers of the well-known Terry type.

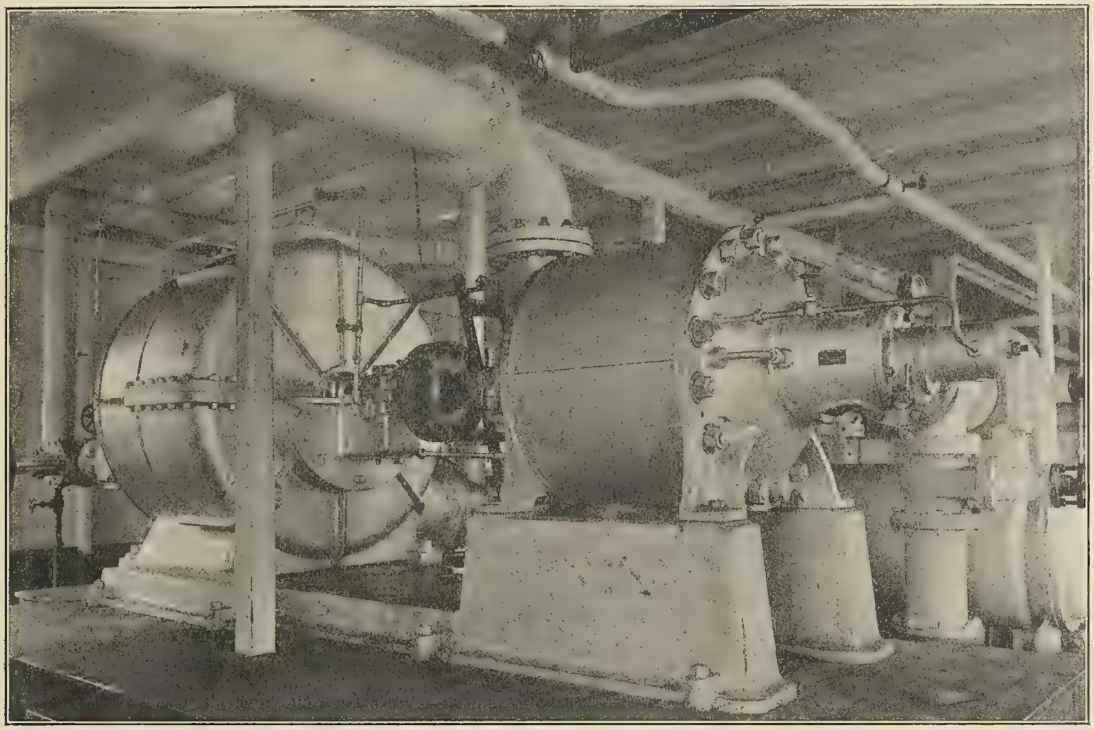
The glands or stuffing-boxes are of the labyrinth type. Composition strips are set in a sleeve on the turbine shaft; these strips project above the surface of the sleeve, and are so placed that they are in approximate contact in an endwise direction with portions of the gland pot or body, which is fastened to the turbine case. In addition to the rings mentioned above each sleeve is equipped with split piston rings, which bear on their peripheral surface against a portion of the gland body. The portion of the gland between these two sets of rings is cored, and a connection is made between the high and low-pressure gland so that any steam which might get by the first set of rings on the high-pressure gland is collected in this cored space and led to the low-pressure gland; in this way absolutely sealing the low-pressure stage. The bearings of the machine are supported from the turbine case, so that any change of temperature, due to load, etc., in no way affects the alinement of the set. The pump and turbine are directly connected through a rubber bushed flexible coupling.

The contract with the Government called for a steam consumption test of the unit six hours in duration. The guarantee included 31.9 pounds of dry steam at 180 pounds pressure and 26 inches vacuum per water-horsepower delivered. Assuming a pump efficiency of 70 percent, which is guaranteed, this would mean a guarantee of 22.25 pounds of dry steam per brake-horsepower per hour at the pressure and vacuum above mentioned. The test was made by United States engineers, assisted by engineers from the Allen Engineering Company.

The speed of the turbine was taken by means of an indicator on the end of the pump shaft. The steam pressure was measured by a gage in the steam line close to the throttle, and its quality by means of a throttling calorimeter. The steam consumption was measured in the usual manner by means of two tanks carried on standard scales and used alternately for weighing the discharge from the air pump. The vacuum was measured by means of a mercury column; all temperatures were taken in mercury wells. The discharge water from the turbine pump was measured by means of a weir located on the bank, the water being carried to the weir by means of one of the high-pressure hoses. The total pumping head was measured by means of gages placed at the pump in both suction and discharge lines. All gages, scales and other measuring instruments were carefully calibrated and tested.

The steam consumption guaranteed covered the total consumption of the turbine and the wet vacuum pump. The exhaust line from the latter was therefore temporarily diverted from the feed heater into the condenser, in order that its exhaust might be included in the total. The conditions prevailing during the test were not exactly in accordance with those on which the guarantee was based. The corrections,

however, covering differences in steam pressure, vacuum and water-horsepower, were agreed upon beforehand. The results of the test, which proved very gratifying, showed an actual steam consumption of only 28.4 pounds per water-horsepower, against 31.9 pounds guaranteed, this being equivalent to 19.85 pounds actual for brake-horsepower against 22.25 pounds guaranteed. This shows an economy 11 percent better than



TERRY STEAM TURBINE AND ALBERGER TURBINE PUMP ON THE MISSISSIPPI GRADER

was stipulated. At the same time the capacity of the unit in gallons per minute against the total head showed 11.5 percent greater than had been guaranteed.

The general summary of the test follows, the figures being averages of twenty-five readings taken 15 minutes apart. The date of test was Dec. 20, 1911:

Average steam pressure	180.9 pounds.
Quality of steam	95.02 percent.
Barometer	29.49 inches.
Vacuum referred to 30 inches barometer.	25.05 inches.
Pump discharge in gallons per minute..	1,348.9
Total head, including suction & friction.	487.4 feet.
Suction head	14.4 inches.
Discharge head	207.2 pounds.
Water-horsepower delivered	167.1
Revolutions per minute	1,786
Pounds standard dry steam per water-horsepower	28.4
Pounds standard dry steam per water-horsepower guaranteed	31.9
Pounds standard dry steam per brake-horsepower	19.85
Pounds standard dry steam per brake-horsepower guaranteed	22.25
Pounds standard dry steam, total	4,746
Duty in million foot pounds per 1,000 pounds dry steam	69.85

From the plans it will be noted that a capstan at each end has been placed for towing and mooring purposes. It will also be noted that the three boilers discharge their products of combustion into a single tall stack. The suction will be seen to come from two square wells running down through the center of the hull, each having a suction head. One of these heads passes its water through the condenser and then into the pump, while the other discharges directly into the pump. In order to withstand the very heavy pressures to which the ultimate 8-inch discharge line is subjected, the latter is made of extra heavy pipe.

Twenty-Inch Hydraulic Disposal Dredge

The New York State Barge Canal construction has brought out several novel designs of dredges to meet conditions and the prices obtainable for the excavation. Most of the contracts for excavation have been let during years when the railroads were not building new lines or improving old ones, and consequently were not giving work to the contractors. As a result there has been considerable competition in bidding for the barge canal contracts and the prices have generally been low. Under such circumstances it has been necessary for contractors to go on the work with a plant modern in every respect and especially adapted to do that particular piece of excavation in the cheapest possible manner. This necessitated high plant expense, but it meant that the contractor would have the salvage value of this plant when he completed the work, rather than to have nothing to show but receipted pay rolls for perhaps a like amount of money. In other words, first cost was increased to keep down operating costs—labor was reduced to the minimum by increasing the cost of equipment. Plant is always an asset—receipted pay rolls are not.

Contract 18-B covers a section of the canal 5 miles long, and reaching from Mindenville to Canajoharie. The work comprises the canalization of the Mohawk River and the provision of proper entrances for several streams which will empty into the canal. As the canal for the most part follows the largest channel in the river, at scarcely any point did the entire prism of the canal have to be excavated. For long stretches only a very small percentage would be required. This small percentage might be a thin layer all across the bottom or might be concentrated at the toe of one slope. In other stretches there would not be depth of water for floating

anything drawing over a foot of water. The river often had two channels with low lying islands. The spoil areas, in the main, consisted of the abandoned channels behind these islands. Clearly dumping scows could not be used, as they would be aground on the material they dumped. Flotation was not sufficient for tugs. Some of the spoil had to be deposited on the islands. Unloading of deck scows by derricks and skips and distributing by cars was impossible. A large percentage of the material spoiled had to be placed in dykes which would be fairly compact and impervious to water. The larger stones could be used for paving the slopes as called for by the contract. Test pits were dug at many points, and it was ascertained that most of the material consisted of gravel with quite a large percentage of sand and large stones, the latter being of such size and quantity as to be likely to interfere with the continuous and efficient running of a centrifugal pump. In a great many places the gravel and boulders were so compacted as to prevent the successful employment of a hydraulic dredge with a powerful cutter head.

DREDGING PLANT ON THE NEW YORK STATE BARGE CANAL, WORKING BETWEEN MINDENVILLE AND CANAJOHARIE

After the foregoing facts had been established, the Bucyrus Company, of South Milwaukee, Wis., designed and installed for the contractors, S. Pearson & Son, Inc., the following plant to handle the work: It was decided to do the actual digging with two dipper dredges digging side by side and capable of excavating the entire prism. Between them were located a stone scow and a hydraulic disposal plant. There were thus four hulls lying side by side across the prism. This was not objectionable, as there were no waves nor any traffic to be hindered. The force of the current during most of the year is slight.

Timber hulls were used throughout as being cheaper and affording sufficient length of life to outlast the work. Bituminous coal was used for generating the steam for the engines throughout.

The two dipper dredges are of the usual patterns except that thrusting engines are provided on the boom to make it possible to dump the dipper at varying distances away from the side of the dredge. They have 3-yard dippers, timber booms, timber handles and vertical forward spuds with an engine for each for raising them and pinning up the dredge. The swinging circle is of structural steel and mounted on top of the trusses. The swinging drum is compound geared to an independent double-cylinder engine.

The main engines are 14 by 16-inch double cylinder, single geared to the hoisting drum shaft, which in turn is geared to the backing drum shaft, this shaft carrying also the stern spud drum. The hoisting is by three parts of wire rope, the backing being wire rope also, both drums being grooved. The boom swings through an arc of 180 degrees. The hulls are 100 feet by 34 feet.

The stone scows are 13 feet wide and 28 feet long, built of timber and arranged as center dump.

The hydraulic disposal dredge has a spud at the stern and one near the bow to keep it anchored. These spuds are hoisted each by an independent engine. A hopper is mounted on the bow on the center line of the dredge.

On each side of the hopper are shaking tables upon which the material is dumped by the dipper dredges. The shaking of these tables works the material into the hopper in a steady stream. The hopper slopes down into the interior of a revolving screen, with holes of such a size as to allow the hydraulic material to pass through while retaining the stones to use for paving.

The material which passes through the holes falls into a sump below the water level and flows into the suction pipe of the 20-inch centrifugal pump together with the proper quantity of water, which is admitted to the sump from the river through a hole below the waterline of the dredge. The suction pipe leads aft to the pump, which is located at the stern. From here the material is discharged through a floating pipe line, which may or may not terminate in a shore pipe line, depending upon whether there is flotation on the spoil area.

The large stones which were refused by the screen pass by gravity to the lower end of the screen and from there into a steel box or skip resting on the deck. This skip may be raised by wire ropes hung from a rolling carriage mounted on two horizontal rails which extend entirely across the dredge with extensions, which either reach out over the stone scows or can be raised to a vertical position to allow another dredge to come alongside. When the skip is loaded it is raised, moved out over the stone scow and dumped by power. Before removing the loaded skip the mouth of the screen is closed by a door to prevent the stones from being discharged until the skip is ready for a new load. The operation of the door and of the skip is controlled by one man.

The two dipper dredges move ahead in the ordinary way, by dropping the dipper on the bottom, raising the forward spuds, pulling the dredge toward the dipper by the backing rope,

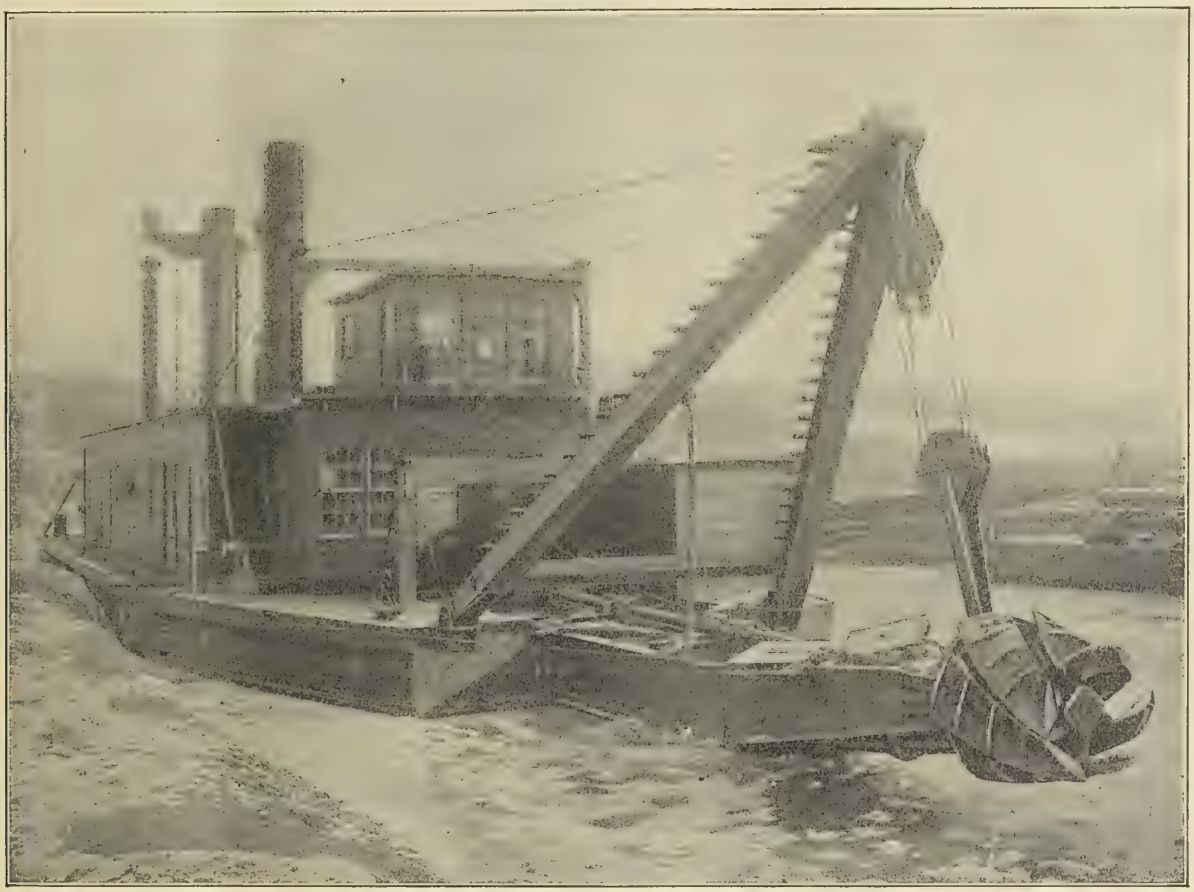
dropping the forward spuds and straightening up the stern spud.

The hydraulic disposal dredge is moved ahead by raising the forward spud and pushing down the stern spud by means of its engine. This spud is kept from assuming a vertical position, so that by pushing down with the spud the dredge is moved ahead away from the spud point. The forward end of the hydraulic disposal dredge is kept from swinging by lines to one of the dipper dredges.

Of course, the size of the holes in the revolving screen may be varied if any decided change should occur in the nature of the material being handled.

A 20-Inch Morris Suction Dredge

The illustration on this page shows a 20-inch Morris suction dredge owned by the American Pipe & Construction Company, and used by them on their New York State Barge Canal contract at Canajoharie, N. Y. An exactly similar dredge has been used at Utica, N. Y., and the Morris Machine Works, Baldwinsville, N. Y., have in addition built five other 20-inch dredges that are in service on the New York State Barge Canal.



MORRIS SUCTION DREDGE USED ON THE NEW YORK STATE BARGE CANAL

The hull of the dredge is of wood, with two heavy steel girders running fore and aft. Its length is 138 feet and its width 42 feet. The main dredging pump has a 20-inch suction and discharge, which is fully steel lined, and of steel construction throughout. It is directly connected to a vertical triple-expansion Morris engine that indicates 750 horsepower at 225 revolutions per minute. The cylinders are 15, 22½ and 36 inches in diameter, with a common stroke of 18 inches, and the engine operates with 200 pounds steam pressure. The pump shaft is 10 inches in diameter in the main bearing, and there is a five-collar steel horseshoe thrust to take the pump end thrust. The pump runner is 78 inches in diameter. This outfit has delivered through as much as 4,000 feet of pipe line with an elevation of 10 feet.

The boiler plant is arranged in two batteries, two 180-horsepower boilers to each battery. A surface condenser is used, having vertical air pumps and centrifugal circulating pumps; boiler feed pumps, service pumps, etc., are all of vertical Admiralty type.

The cutter ladder is of very heavy steel construction. The cutter shaft is 8½ inches in diameter, and the drive is through cast steel gears with cut teeth. The cutter-driving engine is a 12-inch by 12-inch double-cylinder horizontal engine placed on the deck. The winding engine is 8 inches by 12 inches, double cylinder, operating five drums. A 15-kilowatt electric lighting plant is installed, and the construction of everything throughout is of most substantial character. The dredge was designed with the object in view of eventually being used in salt-water service, as work on the New York State Barge Canal will not be of long duration. The canal is divided into three divisions—the eastern, middle and western. While in construction the canal is to be opened not earlier than May 15.

The Danish Suction Dredge Graadyb

BY AXEL HOLM

During the year 1909 the firm Copenhagen Floating Dock & Shipyard, Copenhagen, Denmark, built and delivered to the Danish Government's Water Construction Department the 900-ton suction hopper dredge described in the following:

In its working methods it comprises many radical departures from earlier-known dredges, and during last year's exhaustive trials these have proved to be very successful. The main idea was to get the discharge of the sand and water mixture from the suction pump into the hold to be a good deal below the overflow of the surplus water, thus giving the sand better conditions for settling down. With a total of 450 indicated horsepower working at the pump the sand room was filled in 36 minutes, and only very few traces of sand were found in the overflow, which must be called an exceedingly good result for a dredge of this size.

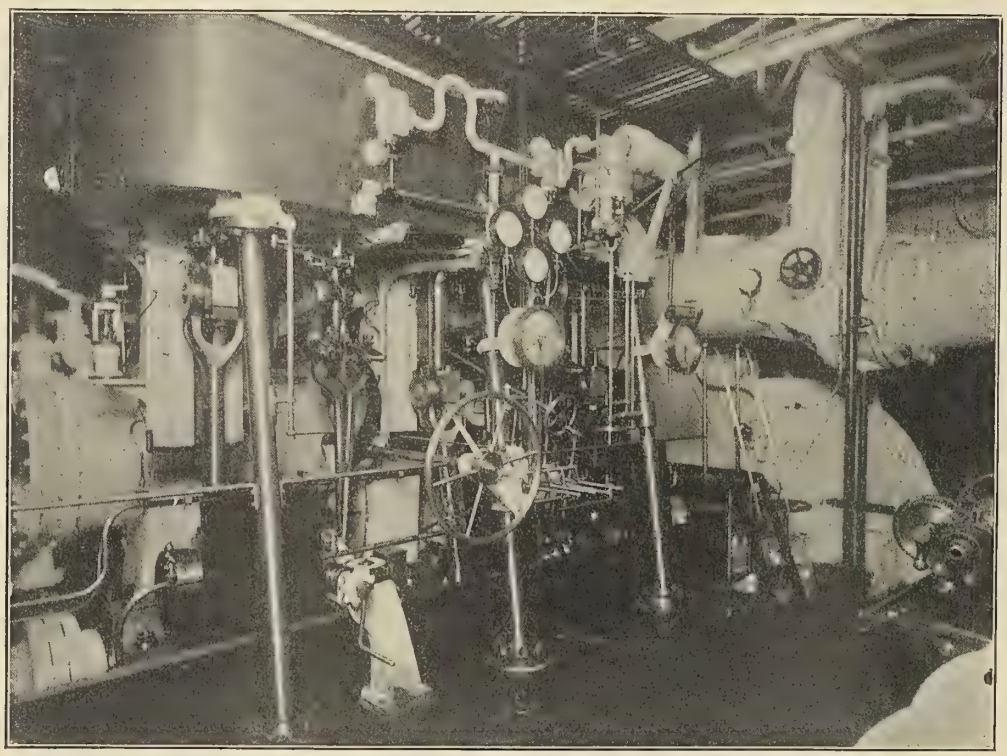


FIG. 1.—ENGINE ROOM OF DREDGE GRAADYB

She is engaged on the rough western coast of Denmark in the North Sea, her main duty being to keep the channel clear to the harbor of Esbjerg, and these conditions also call for a good and steady sea ship.

She is built to the Bureau Veritas' class, I. Div., 3/3 R. I. I. P. R., Special Survey, with dimensions to the mark G., and her main dimensions after the Bureau's rules are: Length between perpendiculars, 185 feet; breadth, molded, 34 feet; depth, molded, 15 feet, and the draft loaded being about 13 feet 6 inches. Her scantlings and other details are given on the plans and 'midship section. The fore-and-aft parts of the deck are raised, having a length of, respectively, 46 feet and 76 feet, and laid with Oregon pine, while the 'midship deck is bare steel. The bulwark is solid steel plate around the fore and 'midship decks, while stanchions and pipe rail are fitted aft. The machinery is placed aft, the sand bin 'midship and the living quarters forward, while the maneuvering bridge, with pilot house, is aft on top of the engine and boiler casing, and here also the boats are stowed. One light, seamless steel mast stepped on the fore deck, together with the rather huge smokestack-way aft, is the only rigging provided for. On the mast is arranged a crow's nest for lookout and commanding purposes, and also a light wooden derrick boom.

The machinery consists of a triple-expansion, reciprocating steam engine, indicating about 525 horsepower, and arranged for driving both propeller and sand pump. Steam is furnished by two Scotch boilers, 9 feet 8 inches long by 10 feet 3 inches diameter, with two furnaces each. In light condition on the trial trip the ship averaged 8.75 knots. The rotary sand pump is built of heavy steel plates and angles, with cast steel fittings of the company's own particular design, with the fan wings and other places subject to hard wear covered with special hard steel linings, and it has proved very successful through the trials passed. The suction pipes are two in number, one on each side of the ship, but only one being used at a time, 30 inches in diameter, and made of heavy seamless steel tubing without any stiffening whatever, and also without the hydraulic or spring shock absorber generally considered necessary; the pipe and its double-acting swivel connection to the ship's side being strong enough to resist all strains and stresses playing in.

The suction openings on both sides are below the waterline in order to lower the lifting height of the pump, and they are closed with sliding valves operated by hand-wheels and spindles, and so are the openings for the flow pipe connections, which are also 30 inches in diameter, and on both sides just above the light water-line. One of these huge valves can be seen in the view of the engine room, Fig. 1. The swivel couplings are made of cast steel, and their construction will be easily understood from Fig. 5. They are mounted on cast

steel shields sliding up and down in guides, and the pipes can thus be stowed on deck when the ship is under way, leaving only the guide tracks projecting outside the shell.

to the hopper room through rectangular, hand-operated, hinged valves, 24 by 15 inches, three on each side, as shown on the general arrangement plan and the 'midship section. There

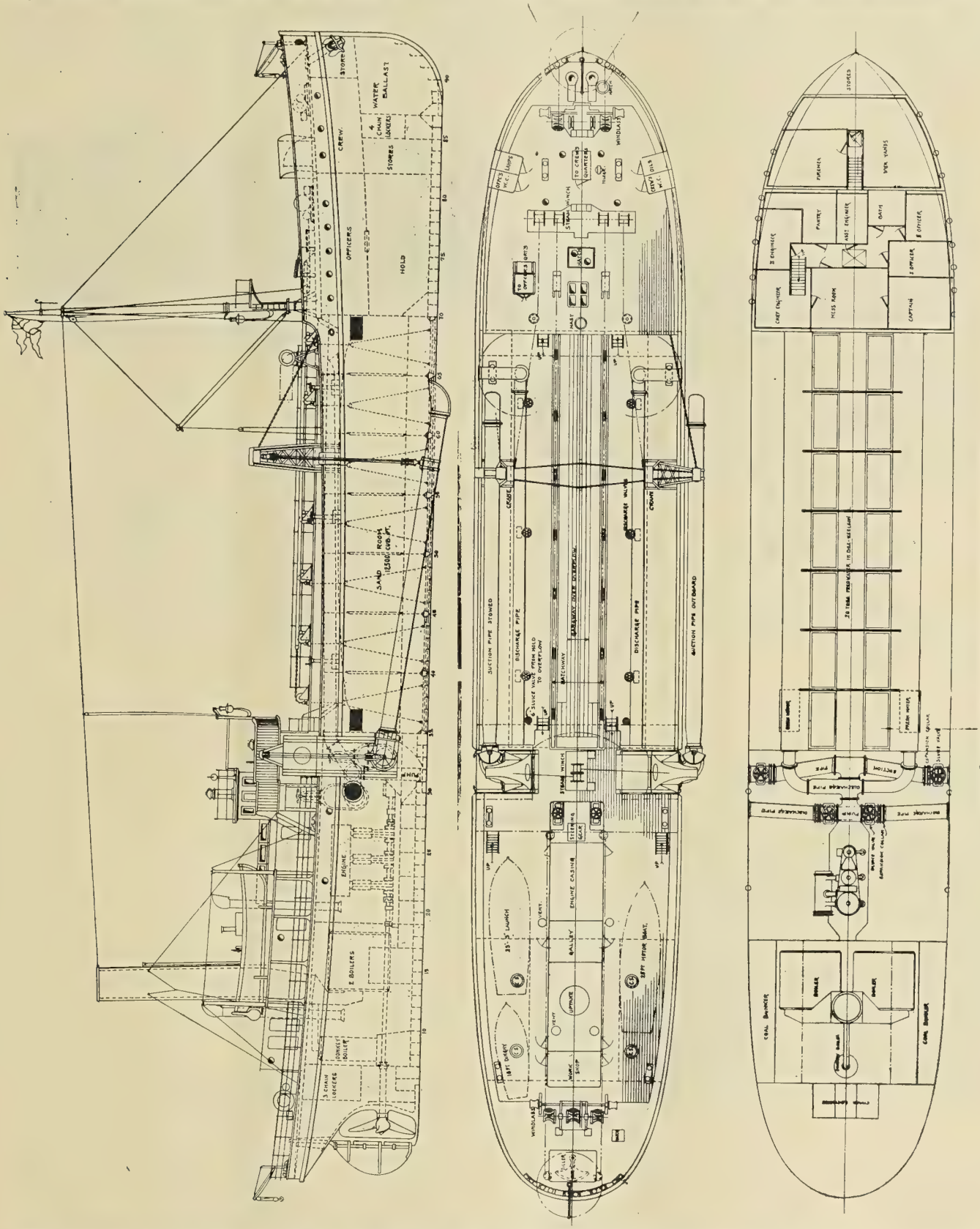


FIG. 2.—GENERAL ARRANGEMENT PLANS OF THE GRAADYB

The discharge pipes to the sand bin are also two in number, branched off from the top of the pump and are used simultaneously. They are 24 inches in diameter, made of seamless steel tubing and laid on top of the deck amidship as far outboard as practical, and opening down through the deck

is no valve between these pipes and the pump, the forward ends acting as reserve height for the pump. In the engine room is also installed an independent reciprocating water pump connected to a 3-inch pipe system for washing out the sand bin and the sand pipes, the valves and main pump.

The hold is arranged as one continuous sand bin, 69 feet 6 inches in length and of 2,500 cubic feet capacity, with sloping sides as ordinary. The box keelson is utilized as a feed-water tank, and on both sides of it are seven hopper doors, 9 feet 3 inches by 4 feet 3 inches, made of steel plate with angle-bar frame and sheathed with yellow pine on upper and lower sides. The doors are hinged outboard, and the hinges are brought up well clear of the ship's bottom. The closing of the

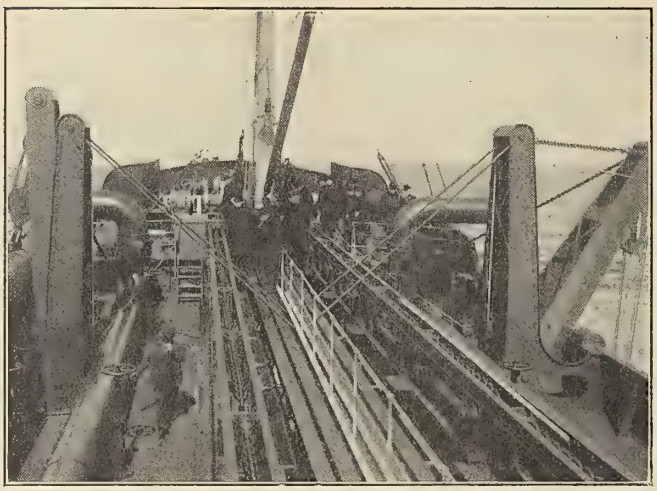


FIG. 3.—DECK VIEW LOOKING FORWARD

hopper doors is done in the good old Dutch way by chains from their inboard edges, two from each door brought together on a compensation link from which single chains lead up over heavy cast steel rollers on top of the hatch coaming. The chains are then connected to two channel bars running longitudinal on both sides of the rollers. These channel bars are worked by the forward maneuvering winch through a fixed purchase with steel wire ropes. Just below the rollers is a solid steel link fitted in the single chains with a rectangular

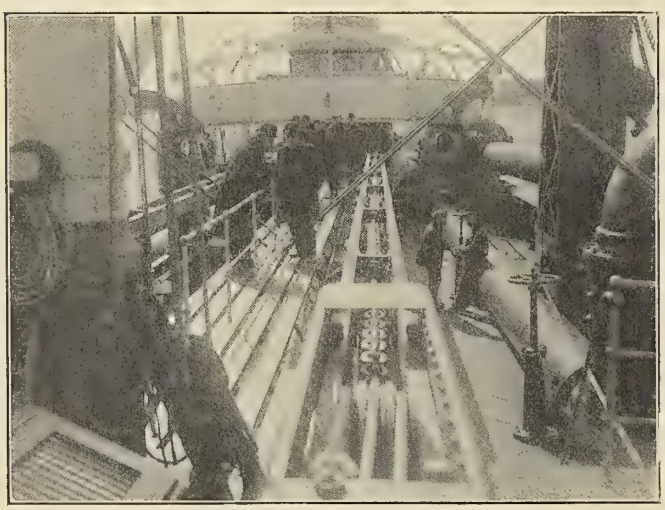


FIG. 4.—DECK VIEW LOOKING AFT

hole in it for locking the hopper doors by means of a steel wedge resting on the hatch coamings. This arrangement relieves the strain from the winch and purchase when doors are closed, and also allows the doors to be worked independently.

Over the whole length of the hold is a hatch opening, 8 feet 9 inches wide, with solid steel coaming, the upper edge of which is parallel to the keel; inside the coaming is arranged a steel girder 24 inches deep, which together with the coaming proper carries the chain rollers as before mentioned. Two feet below the top of the coaming is the top of the overflow, arranged as a kind of a trench in the center of the ship, running the full length of the sand bin and slooping down at both ends to transverse conducts, which lead the overflow water overboard through big rectangular holes in both ends of the hold and on both sides of the ship below the main deck. A gangway is arranged over the overflow trench between the hatch coamings for access to the wedge locks.

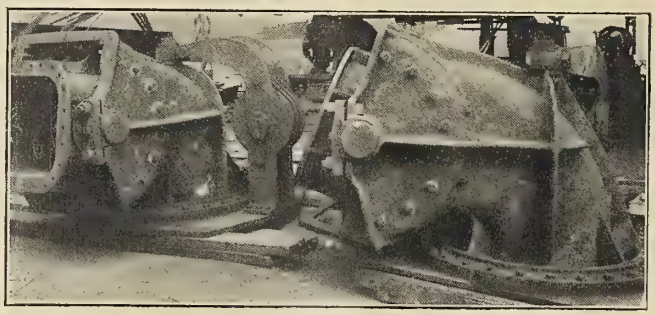


FIG. 5.—SWIVEL COUPLINGS ON SUCTION OPENINGS

There is a maximum head of about 2 feet 9 inches and a minimum of about 1 foot 9 inches from the lower edge of the discharge valves to the top of the overflow, which together with the transverse distance of about 8 feet provides ample time and conditions for the sand to settle down before the overflow is reached, and, as before said, this arrangement is giving an almost sand-free overflow. It will also be seen that the deck is kept entirely free from the overflow water. When

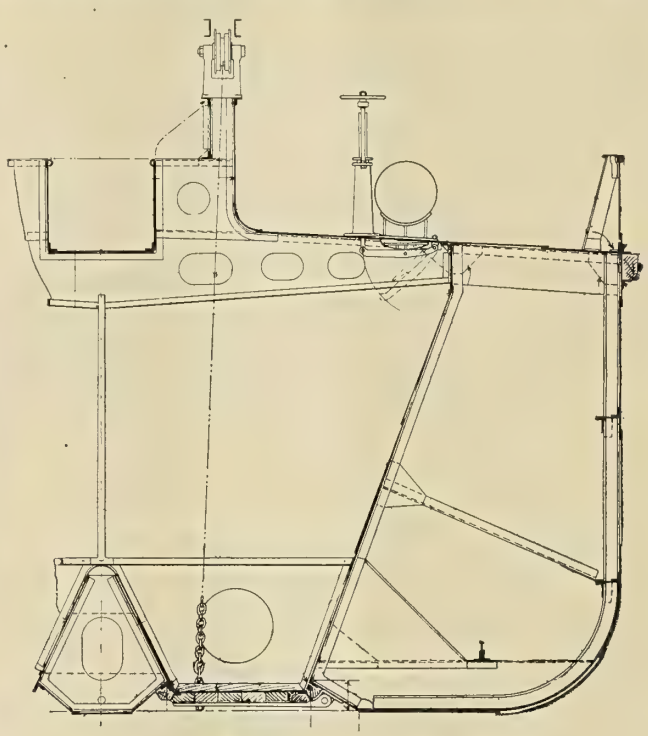


FIG. 6.—SECTION THROUGH HOLD

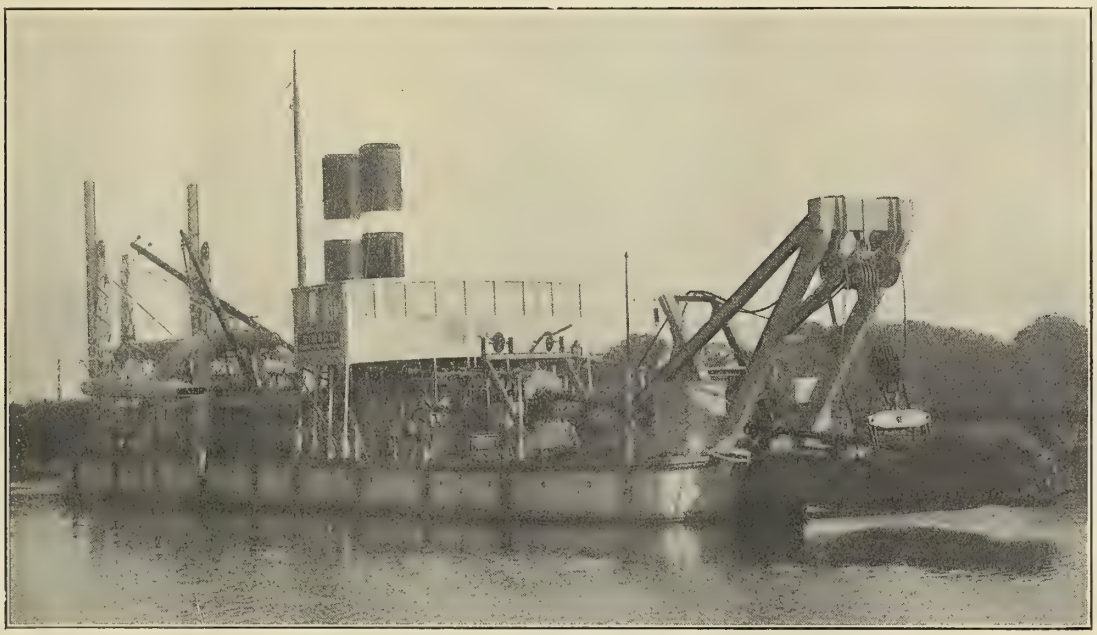
the sand bin is filled and the pump is stopped the water standing on top of the sand will drain overboard back through the pump, and a 6-inch sluice valve to the aft transverse overflow is also provided for this purpose. When the pump is to discharge through flow pipes, the six hold discharge valves are kept closed and the one side discharge valve in the engine room opened. For loading into barges through the forward swinging ends of the main discharge pipes all the valves are simply kept closed.

The deck machinery for handling the suction pipes is very complete and substantial. The pipes are about 63 feet long from the center of the shell hole to the tip of the nozzle, and are designed for a normal depth of dredging of 40 feet below the waterline. Two cranes for each pipe, one forward and one aft, are provided for raising the pipes and sliding them in on the deck. Figs. 3 and 4 showing one pipe stowed on deck and the other one working outboard give an idea of their general arrangement. The forward one is a tipping crane built of plates and channel bars, and so arranged that it will tip inboard and swing the pipe on deck automatically when the lower purchase block mounted on the pipe is up and caught by the big hooks seen suspended from the upper purchase block. The steel wire hoisting rope leads over pulleys to the steam winch on fore deck, the same that operates the hopper doors, as before mentioned. Double chains between the tops of the swinging and the fixed legs of the crane stop it in the outboard position, and another chain from the top of the swinging leg and fixed well forward acts as side guy. The after cranes are also built of plates and angles, and operated both by hand and by an independent steam winch on the deck right behind the cranes. As will be seen from the plans and Fig. 6 its outboard side forms a continuation of the tracks for the swivel coupling with a neck projecting out over it, bearing fixed sheaves for the lifting purchase. On the shield bearing the swivel coupling are other sheaves fitted for the lifting wire rope which is worked by the steam winch. When the coupling is on top it is locked simply by inserting a pair of stop pins, and the whole crane is then rolled inboard on heavy cast steel tracks bearing teeth bars on their tops. Combined gear and bearing wheels are engaged in the teeth bars and worked by a single hand swing through a screw and worm gear.

The anchoring and warping machinery consists of a steam windlass forward, with two chain wheels for the bow anchors and two drums for the warping chains, which lead over heavy roller chocks on the plate bulwark in the bow and another steam windlass aft with three chain drums and rollers on the bulwark. An anchor crane is also fitted forward and aft, and under each windlass are ample chain lockers arranged. The rudder is worked by a steam gear placed on the main deck inside the engine casing and just below the wheel on the navigating bridge. The ship is lighted throughout by electricity, having also two arc lamps on deck for night work; the generator is installed down in the engine room.

Under the living rooms forward is a water ballast tank in the bow, then comes the forward chain lockers and stores, and right forward of the sand bin is a roomy hold with hatchways, and the derrick boom is arranged to fit on both sides of the mast, so that it can be used handling goods to this hold also.

The small boats, stowed aft on the casing top, are: One 16-foot dinghy, one 23-foot 3-inch launch with anchor-handling gear, and one 25-foot motor boat with crude oil motor.



DUTCH SUCTION DREDGE SIMSON

A Dutch Suction Dredge

A suction dredge with clay cutter was built in the year 1911 by the "Werf Conrad" Company, of Haarlem, Holland, for the Kölnische Tiefbau Gesellschaft for their works at Hamburg. This is one of the most powerful dredgers of its kind. It is arranged with a suction pipe in a central well, carrying a clay cutter for working to a depth of about 45 feet below water, but the piping arrangement can also be changed for working as a barge-unloading dredger.

The vessel, which is named the *Simson,* has the following dimensions: Length, 150 feet; width, 33 feet; depth at ship's sides, 12½ feet; mean draft in working order, 6½ feet.

The vessel is fitted with two triple-expansion engines of a total indicated horsepower of 1,000, each driving a powerful sand pump. These pumps can be arranged in parallel or in series, according to the distance to which the stuff is to be pumped. Besides these two there is one triple-expansion engine of 200 indicated horsepower driving a centrifugal water pump to be used when the dredge is used for emptying barges. The cutter engine driving the clay cutter is mounted on top of the ladder, and develops 200 indicated horsepower. A complete self-contained condensing plant, consisting of a surface condenser and a set of compound horizontal engines, driving all necessary pumps, takes the steam of all the above named main engines and also of all auxiliary engines, pumps, winches, dynamo engine, etc.

The handling of the dredge is absolutely centralized. It works on two spuds and two side lines, worked from one big four-barrel winch with heavy friction clutches and band brakes. The ladder is hung from a separate steam winch.

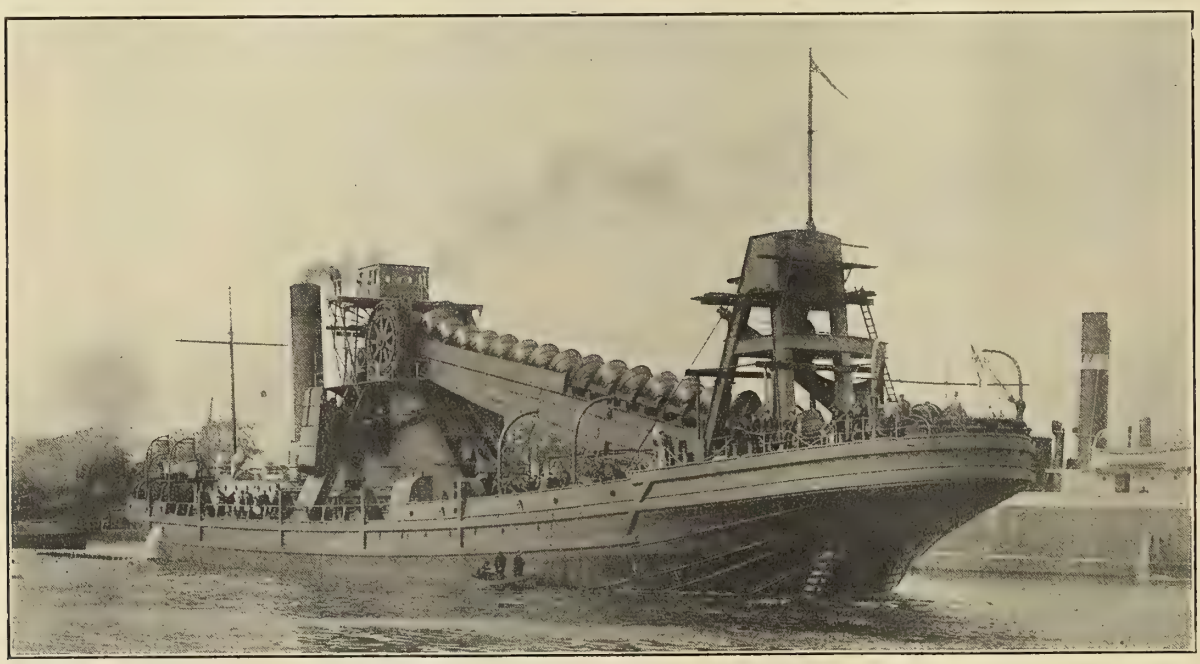
All handles for clutches, brakes, reverse gear and steam valves of these two winches are brought together in the pilot house. Here are also the necessary hand-wheels and handles for manipulating the cutter engine, telegraphs to the engine room and a complete set of pressure and vacuum gages for boilers, engines and suction and delivery of sand pumps. From this pilot house one man can easily work the whole dredge. Two marine boilers, having a total heating surface of 4,300 square feet, produce the necessary steam at a working pressure of 160 pounds per square inch.

This machine can easily dig and force ashore a quantity of 75,000 cubic yards per week, as has been proved in actual work. This quantity can, nevertheless, not be considered as a maximum, because a good many hours have been lost each week in adding or taking away floating sections of the discharge pipe line, which has been inevitable by the nature of the work.

Two Large Canal and Harbor Dredgers

Messrs. William Simons & Company, Ltd., Renfrew, have just completed to the order of the Isthmian Canal Commission a dredger which will be employed on canal work of the very hardest description. The dredger, which is called the *Corozal*, is of the twin-screw type, and made the voyage to the Pacific Coast under her own steam. She has a hopper capacity for 1,200 tons dredging, and the bucket ladder is designed to dredge to a depth of 50 feet.

The dredger is propelled at a speed of 10 knots by two sets of triple-expansion surface condensing engines, supplied with steam from two cylindrical multi-tubular boilers, constructed to Lloyd's requirements for a working pressure of 180 pounds per square inch. A complete outfit of most modern auxiliary machinery is provided in the engine room, including independent air pumps, circulating pumps, feed pumps, feed heater and filter, etc.



DREDGE COROZAL FOR THE ISTHMIAN CANAL COMMISSION

The dredging gear is of massive description, and is arranged to give three speeds of buckets to suit the various kinds of material to be dealt with. The dredging gear can be driven by either of the main propelling engines. Two sets of buckets are provided, one of 54 cubic feet capacity for dredging soft material, and one of 35 cubic feet capacity for dredging stiff clay. The bucket ladder is a steel girder of exceptional strength, and an idea of the enormous strength of the bucket chain may be conveyed by the statement that the ladder, with its chain of buckets, links and pins, weighs upwards of 240 tons. The upper end of bucket ladder is supported on an independent pivot shaft, and the lower end is controlled by powerful steel wire rope tackle and an independent steam hoist gear, which is designed for raising the ladder at a speed of 10 feet per minute.

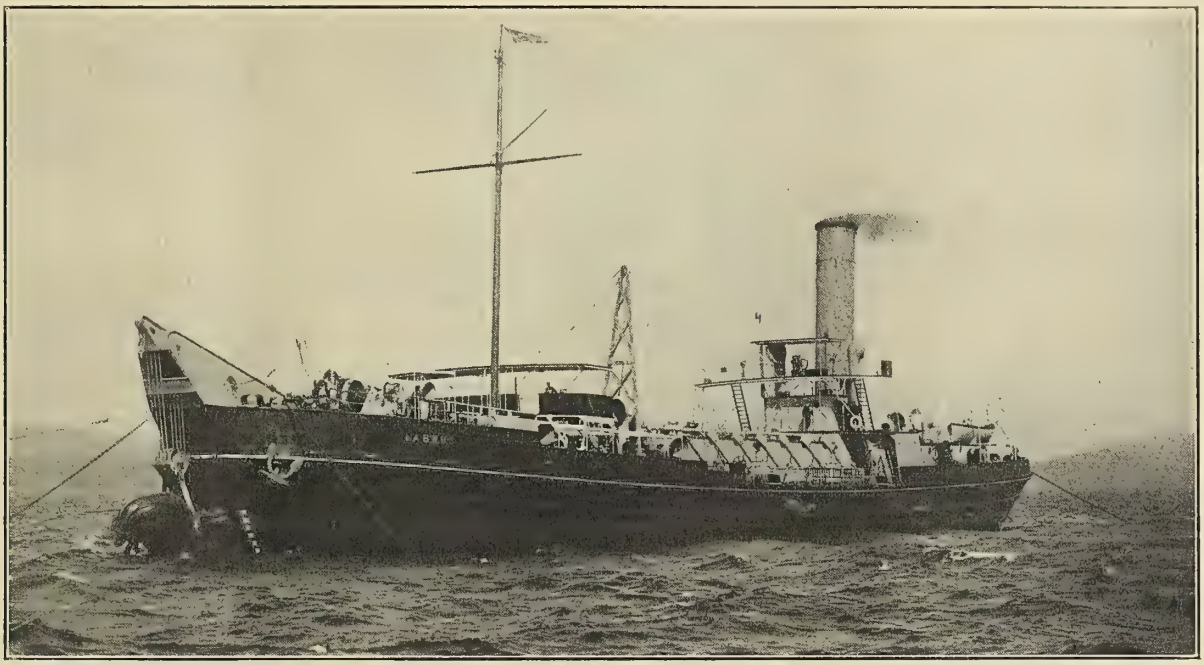
Steam maneuvering winches are fitted at the bow and stern, each driven by independent two-cylinder engines, and each barrel is fitted with friction clutch and brake to enable the mooring chains to work independently of each other, or simultaneously, as may be required. Shoots are provided for loading into the vessel's own hopper, and there are also overboard shoots controlled by independent steam winches for loading into barges alongside. The hopper doors are controlled by independent hydraulic gear.

Steam steering gear, full electric light installation and refrigerating plant are provided, also cabins for officers and comfortable quarters for the crew and the most modern equipment for a vessel of this class.

In the prosecution of their project for the improvement of the depths in the Esplanade Channel, Durban Bay, and for the opening of new wharves on the west side of the bay, the Government of the Union of South Africa recently placed an order with Simons & Company for one of their "Simons" patent cutter suction hopper dredgers. This new dredger, named the *Labrus*, was delivered at Durban towards the end of last year. The bottom of Durban Bay, where the dredger is employed, is composed almost wholly of clay of a very hard nature. The dredging of this character of material by means of a spiral rotary cutter is only a recent development in dredge building, the first hopper dredger of this type being

the Simons dredger *St. Lawrence*, constructed recently to the order of the British Admiralty.

The *Labrus*, a photograph of which is reproduced on this page, is a twin-screw hopper vessel of 2,000 tons carrying capacity. Two sets of triple-expansion, surface condensing engines are fitted aft for propelling the vessel at a speed of 10 knots, and there is an independent set of triple-expansion engines for driving the dredging pump, with a complete installation of auxiliary machinery in a separate engine room immediately in front of the hopper compartment. Steam for the propelling and pumping engines and all machinery throughout the dredger is supplied by three large marine type steel boilers.



TWIN-SCREW HOPPER DREDGE LABRUS

The dredging pump is of the most massive and powerful description to withstand any shocks which may be sustained when dredging in clay mixed with stones. The suction pipe is carried on a girder led through a well forward, and is of sufficient length to enable dredging to be done at a depth of 45 feet below the waterline. The dredger has also been designed for cutting its own flotation.

The cutter at the mouth of suction pipe is driven through a line of shafting, fitted on the upper side of the suction frame, and by machine-cut steel gearing actuated by a set of powerful independent compound condensing engines. In addition to the usual winches for mooring from the deck at the bow and stern a special winch is placed amidship from which the moorings are led along the suction frame to fair leads at the lower end.

The hopper is fitted with Simons patent arrangements, whereby the contents of the hopper can be discharged either through the doors in the ordinary way or over-side by the pump for land reclamation. In addition to loading into its own hopper the vessel is arranged to discharge into barges moored alongside or through a pipe line.

The Howden system of forced draft for steam boilers, as developed by Messrs. James Howden & Company, Ltd., of Glasgow, is well known to marine engineers, but its application to the power plants of dredges is a development that is sometimes overlooked. Where dredging machines are kept constantly at work a saving in fuel consumption is essential.

Electrical Operation of Dredges

BY H. W. RODGERS

Although not an entirely new field for electrical enginnering, still there are so few motor operated hydraulic-suction dredges in existence that mention of the 20-inch dredge, owned and operated on the New York State Barge Canal, at Fairport, N. Y., by the H. S. Kerbaugh Company, may be of interest.

This dredge is equipped with a centrifugal pump, having a capacity of 600 to 700 cubic yards an hour, driven by a 700-horsepower, 375 revolutions per minute, 2,200 volts, 25 cycle, three-phase induction motor. The control apparatus consists of a drum controller, which handles the secondary current of the motor only, and an iron grid heavy duty starting rheostat, the primary being taken care of by means of an automatic oil switch.

The cutter machinery is driven by a 200-horsepower, 500 revolutions per minute, 2,200-volt, three-bearing induction motor, geared direct through a slip-friction clutch, the control consisting of a reversible drum controller with starting resistance.

For raising and lowering the spuds, the cutter head, and operating the head lines, a six-drum winch is used, driven by a 75-horsepower, 500 revolutions per minute, 2,200-volt, variable speed, three-bearing motor, controlled by a reversible-drum controller and rheostat of sufficient resistance to permit of 75 percent speed reduction.

In addition to the above there are two 25-horsepower, 1,500-K.-2,200-volt motors driving service pumps, one 10-horsepower, 750-K.-2,200-volt motor, driving a vacuum pump, two 5-horsepower, 1,500-K.-2,200-volt vertical motors, driving bilge pumps and a 10-kilowatt 2080/110-volt transformer for lighting purposes. This transformer also furnishes power for a 1.5-kilowatt motor generator set, used in connection with the searchlight on the bow of the dredge.

The switchboard, consisting of one incoming-line panel and three feeder panels, together with the starting compensators for the constant speed motors, are placed in the stern of the dredge, where the shore cable from the transformer barge enters at a tension of 2,300 volts.

Power is supplied by the Rochester Railway & Light Company, at a tension of 16,500 volts over a fifteen-mile transmission line, paralleling the canal, and stepped down to 2,300 volts through three 250-kilowatt transformers located on the barge which follows astern of the dredge.

The transformer barge is of heavy wooden construction, housed to protect the apparatus from the weather and, in addition to the transformers, contains suitable lightning arresters, choke coils and primary oil switch. Connection between the transformer barge and the transmission line is made by means of three flexible insulated cables, each cable being equipped with a shoe for sliding along the transmission line, the interaxial distance between conductors being maintained by a triangular insulated spreader. Between the barge and the dredge a 600-foot, three-conductor, 2,300-volt, stranded, weather-proof, armored cable is used, which permits of considerable range of operation without shiftng the connections between transformer barge and transmission line, and it might be both advisable and desirable to use a three-conductor armored cable of similar construction between the transmission line and the transformer barge, owing to the increased range of operation and decreased time required to make change in connections.

In comparison with the steam dredge, the electric equipment is much cleaner, more compact and can be operated a greater number of hours per month, owing to the short time required for cleaning and overhauling on account of the reliability of the machinery.

The cost of operation may be greater or less, depending upon the cost of electrical power as compared with the cost of coal and water, but it should be remembered that the initial cost, repairs and labor, are considerably less on the electric dredge than on the steam dredge.

In some localities the question of boiler feed water is a serious problem, and unless an elaborate filtration plant is installed at considerable expense, the delays caused by frequent cleaning of boilers becomes serious.

At the present time, with the numerous electric power plants throughout the country, and the facilities for transmitting large amounts of power through great distances, it is safe to assume that the electrical operation of this class of machinery is possible in any locality, and from the results already obtained it is evident that the electric dredge has come to stay.

The electrical equipment on the dredge described above was furnished by the General Electric Company, Schenectady, N. Y.

A German Frühling Dredge

One of several powerful suction dredges, built on the Frühling system, of which the Schichau Company, Elbing and Dantzig, have the exclusive rights in Germany, is the *Pumpenbagger III.*, which this company built for service at Emden. The vessel is 164 feet long, 33 feet 9½ inches beam and 11 feet 9½ inches draft. Reciprocating engines of 700 indicated horsepower, driving twin screws, give the vessel a speed of 9 knots. The total capacity of the holds is 17,660 cubic feet.

The Frühling system of suction dredging has been described in detail in the May, 1909, and May, 1911, issues of

FRÜHLING DREDGE PUMPENBAGGER III., BUILT BY SCHICKAU AT ELBING

INTERNATIONAL MARINE ENGINEERING. In these dredges aft of the engine room the vessel has a channel or well, forming twin sterns. In this well is the dredge suction arm, in which are incorporated the suction pipes and pressure water pipes. The girder arm is supported at the forward end by heavy cast steel pillow blocks, and at the lower end of the girder is a pair of hinges by which the bucket head is attached. The head is practically a huge inclosed rake serrated along the edge with sharp cutting teeth, through the incisors of which is ejected high-pressure water to aid in disintegrating the spoil and make it of suitable consistency to be sucked through the suction pipes into the pumps, whence it is deposited into the hoppers of the vessel.

Design and Mechanical Features of the California Gold Dredge.

At a combined meeting of the American Society of Mechanical Engineers and the American Institute of Mining Engineers, held in New York, Feb. 13, a paper on the above subject was read by Mr. Robert E. Cranston. The first California dredge, built in 1897-1898, was patterned after the New Zealand type, and the present California type dredge is a combination of this type and several others. The buckets are made with cast steel base, pressed steel hood and manganese steel lip. The lower tumbler is a six-sided steel casting with renewable wearing plates over which the buckets pass. They then travel up a structural steel ladder on rollers and over a six-sided upper tumbler which is driven by a chain of cast steel gears. The buckets dump their material into a hopper which discharges into a shaking or revolving screen. The fine material goes through onto gold-saving tables, and the coarse material is stacked aft of the dredge by means of a belt conveyor. The dredge is held in place by steel spuds and moved by means of side lines running to a motor-driven winch. The digging ladder is raised by means of a separate winch.

Battleship Florida, the Latest United States Dreadnought

BY HENDERSON B. GREGORY

The *Florida,* built at the navy yard, Brooklyn, N. Y., is one of two battleships authorized by an Act of Congress approved May 13, 1908, the sister ship being the Utah, built by the New York Shipbuilding Company, of Camden, N. J.

The vessel was designed for a speed of 20.75 knots, with the main turbines developing 28,000-shaft horsepower and at a displacement of 21,825 tons, a performance which was easily attained, as shown by the trial data given later.

Principal Hull Data

Like all recent battleships, the Florida is of the familiar all-big-gun type, with principal dimensions, as follows:

Length between perpendiculars, feet and inches	510-00
On L.W.L., feet and inches	510-00
Over all, feet and inches	521-06
On straight keel, feet and inches	460-00
Projection forward of F.P., feet and inches	11-06
Aft of A.P., feet and inches	0-00
Breadth, extreme, at L.W.L., outside of armor, feet and ins.	88-02⅝
Molded, feet and inches	87-10¼
Depth, molded, main deck at side M.S., feet and inches	44-05⅞
Draft to L.W.L., feet and inches	28-6
Corresponding displacement, tons	21,825
Ratio of length to beam	5.781
Displacement per inch at L.W.L. tons of S.W., tons	73.82
Area of midship section, square feet	2,458
L.W.L. plane, square feet	31,056
Wetted surface, square feet	56,700
Coefficient of fineness, block	.5837
Length of fire-room space, feet and inches	102-00
Engine-room space, feet and inches	60-00

Anchor Windlass

The anchor windlass is of the Williamson Bros. horizontal type. It has two vertical shafts driven by gearing from a horizontal shaft coupled to the engine crank shaft. Each vertical shaft carries on its upper end, above the forecastle deck, a wildcat and locking gear complete. The wildcats can be operated together or independently. The windlass engine is a double-horizontal engine, the cylinders being 16 inches in diameter and the stroke 16 inches.

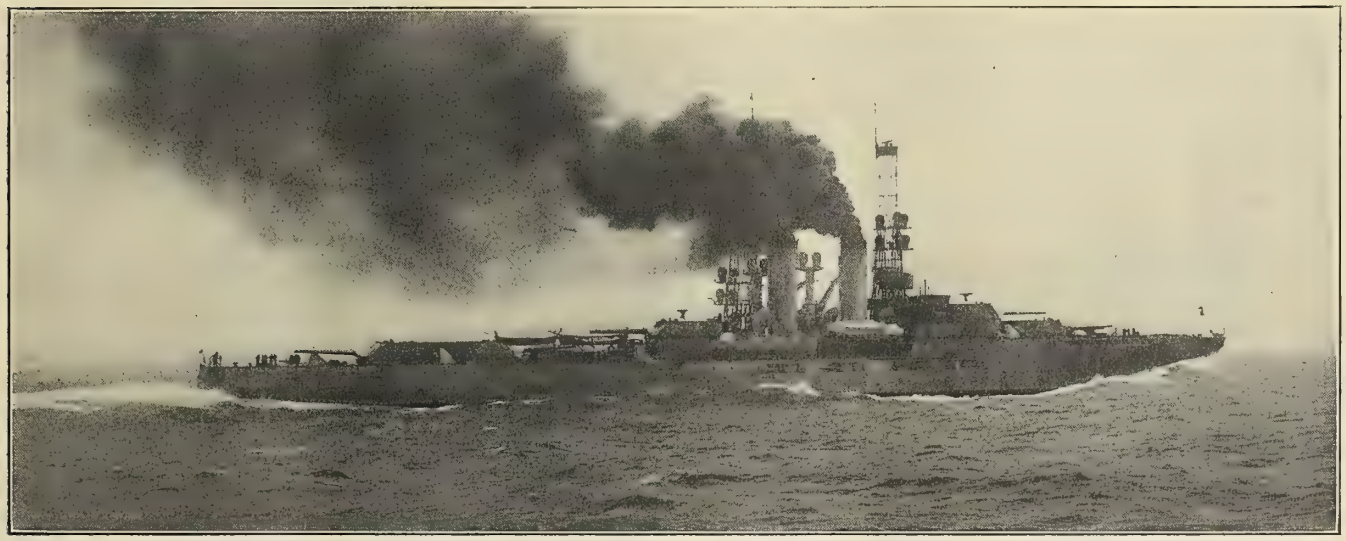
Steering Gear

The steering gear consists of a right and left-handed screw, connected through nuts and links to the crosshead on the rudder stock. This gear is connected through a line of shafting and gears to the steering engine, located in a separate compartment immediately aft of the starboard engine room.

The steering engine is a vertical double engine, with cylinders 17 inches diameter by 14 inches stroke, built by Williamson Bros. It is controlled from the various steering stations by wire-rope transmission or the telemotor; also by a handwheel in the steering engine room.

Four large wheels for hand steering are located in the hand-steering room. Suitable clutches are provided for disconnecting this gear when not in use, which is also the case with the steering engine.

The rudder is of the usual balanced type.



(Photograph by N. L. Stebbins.)

FIG. 1.—UNITED STATES BATTLESHIP FLORIDA RUNNING AT A SPEED OF 22.06 KNOTS

Battery

The main battery consists of ten 12-inch rifles arranged in pairs in five turrets on the center line of the vessel. Turrets Nos. 1 and 2 are on the forecastle deck, the latter being elevated so as to fire over the top of the former. Turrets Nos. 3, 4 and 5 are located on the main deck abaft the smoke pipes. Of this group Turret No. 3 is elevated and Nos. 4 and 5 are placed back to back at a lower level, well astern of the former.

A secondary battery of sixteen 5-inch rapid fire guns is also provided, together with the following smaller guns:

Four 3-pounder saluting guns.

Two 1-pounder semi-automatic guns for boats.

Two 0.30-inch machine guns for boats.

Two 3-inch field pieces.

There are also two 21-inch submarine torpedo tubes.

Coaling Engines

There are two vertical double-cylinder coaling engines, located on the gun deck, port and starboard. The cylinders are 9 inches diameter by 9 inches stroke. Each engine drives, through miter gears, a shaft running fore and aft, to which are geared five winch heads, which are thrown in or out of gear by clutches. The shafts are cross-connected by a shaft and gears, so that either engine can operate all winch heads if necessary.

Ventilation

The various compartments and living quarters are artificially ventilated on the plenum system, by 32-motor driven fans located at convenient points throughout the vessel.

HEATING SYSTEM

The staterooms, quarters and crew's spaces are heated by the ventilating system, steam coil thermo-tanks being introduced in the air ducts for heating the air supplied these spaces. The thermo-tanks can be cut out when desired.

All other parts of the vessel to be heated are provided with the usual pipe-coil radiators.

MAIN ENGINES

The propelling machinery consists of Parsons turbines, designed to run at 330 revolutions per minute, when developing 28,000-shaft horsepower. They are arranged on four lines of shafting, as shown in sketch, Fig. 2. The arrangement provides six ahead and four astern turbines, each low-pressure turbine embodying an astern turbine in the after end. For ahead motion the outboard shafts are driven by the main high-pressure turbines, and the inboard shafts by the low-pressure ahead turbines alone, or in combination with the intermediate-pressure and high-pressure cruising turbines, as described in the following paragraphs.

Four turbines only are used for full speed ahead, steam being admitted to the main high-pressure turbines and expanded through the low-pressure ahead turbines into the condensers. Under this condition the astern and cruising turbines revolve idly in a vacuum, which is maintained through the drain connections.

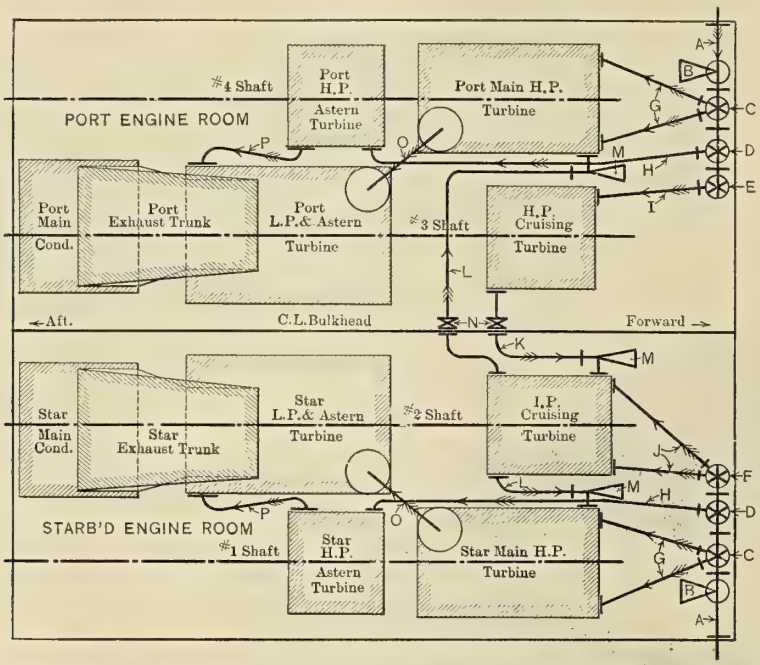
When cruising at low speed all six of the ahead turbines are used, steam being admitted to the high-pressure cruising turbines and expanded successively through the intermediate-pressure cruising turbine, main high-pressure turbines and the low-pressure ahead turbines, exhausting into the condensers; the astern turbines again revolving idly in a vacuum.

For high-cruising speeds only five turbines are employed, steam being admitted to the intermediate-pressure cruising turbine, thence through the main high-pressure and low-pressure ahead turbines, exhausting into the condensers; the remaining turbines revolving idly in a vacuum.

For astern motion all four astern turbines are used. The outboard shafts are driven by the high-pressure astern turbines and the inboard shafts by the low-pressure astern turbines, steam being admitted to the former and expanded through the latter into the condensers. Under this condition all ahead turbines revolve idly in a vacuum.

Self-closing valves are fitted in the receiver pipes between the high-pressure and intermediate-pressure cruising turbines, and between the intermediate-pressure cruising and main high-pressure turbines, as shown in Fig. 2, to prevent back flow of steam when changing from the low to high speed cruising combination or from high cruising to full speed conditions. The turbines are controlled from the working platform, where the regulating valves for admitting steam to the different turbines are located.

There is a main bearing at each end of each turbine for carrying the rotor. Each turbine, except the high-pressure astern, is provided with a thrust block at the forward end, consisting of a number of brass rings, in halves, fitting into corresponding collars on the shaft. The lower half of each ring is for taking the ahead and the upper half the astern thrust.



MARKS	DESCRIPTION OF PART
A	14" Main Steam from Boilers
B	14" Engine Stop and Governor Valve
C	14" Regulating Valve, M.H.P. Turbine
D	13" " " , H.P. Astern "
E	10½" " " , H.P.C. "
F	14" " " , I.P.C. "
G	10½" Steam to M.H.P. Turbine
H	13" " " H.P. Astern "
I	10½" " " H.P.C. "
J	10½" " " I.P.C. "
K	17" Steam from H.P C. to I.P.C.
L	17" " " I.P.C. to M.H.P.
M	17" Self-Closing Valve
N	17" Cut-out Valve
O	43" Steam from M.H.P. to L.P. Ahead
P	29" " " H.P. Ast. to L.P. Ast.

FIG. 2.—SKETCH SHOWING ARRANGEMENT OF MAIN ENGINES AND PIPING

All the main bearings, thrust bearings and line-shaft bearings are provided with a closed system of forced lubrication. A Proell governor is fitted to each line of shafting, the governor mechanism operating the main steam stop valves in the engine room. Each line of shafting has an electrically operated turning gear, consisting of a 5-horsepower, reversible Diehl motor, which engages through gears and worm wheel on the main shaft. Provision is also made for turning by hand with a ratchet.

MAIN TURBINE DATA

	Diameter.	Length.
Motor drums:		
Main H.P., inches	71	114
H.P. cruising, inches	71	63½
I.P. cruising, inches	70	72½
L.P. ahead, inches	97	87⅝
H.P. astern, inches	71	36¼
L.P. astern, inches	71	44⅛
Number of expansions:		
Main H.P. and L.P. ahead, each		6
H.P.C. and I.P.C., each		3
H.P. astern and L.P. astern, each		4
Turbine casings, diameter, inches, each expansion:		
Main H.P.	73¼, 74¼, 75½, 77½, 80, 83½	
L.P. ahead	107½, 111½, 117½, 128, 128, 128	
H.P.C.	72¼, 72⅝, 73⅛	
I.P.C.	72½, 73¼, 74¼	
H.P. astern	72¾, 73¾, 75, 77	
L.P. astern	80, 83½, 83½, 83½	

Length of casing for each expansion and diameter noted above:	
Main H.P., inches	17¼, 17, 17 13/16, 18⅝, 19½, 24 9/16
L.P. ahead, inches	12 13/16, 13, 15 3/16, 19, 19, 19
H.P.C., inches	18½, 18½, 25¾
I.P.C., inches	23½, 23½, 24⅜
Length of casing for each expansion and diameter noted above:	
H.P. astern, inches	9¼, 8¾, 8¾, 9
L.P. astern, inches	9¾, 11 25/32, 11 25/32, 11 25/32
Rows of blading for each expansion:	
Main H.P.	13
L.P. ahead	3 of 7, 3 of 6
H.P.C.	20
I.P.C.	18
H.P. astern	6
L.P. astern	5
Length of blades for each expansion, inches:	
Main H.P.	1⅛, 1⅝, 2¼, 3¼, 4½, 6¼
L.P. ahead	5¼, 7¼, 10¼, 13½, 13½, 13½
H.P.C.	⅝, 13/16, 1 1/16
I.P.C.	1¼, 1⅝, 2⅛
H.P. astern	⅞, 1⅜, 2, 3
L.P. astern	4½, 6¼, 6¼, 6¼

Rotor shaft and bearings:	Length, Inches.	Diameter, Inches.	Diam. Axial, Inches.	Length Over All of Rotor Drum and Shaft, Feet and Inches.
Main H.P.	18¼	14	9	21-07¼
L.P. ahead	29	15	11	25-10¾
H.P.C.	14½	14	11	15-02¾
I.P.C.	14½	14	11	16
H.P. astern	12½	14	9	11-02¾
L.P. astern	29	15	11	With ahead.

Thrust bearings:	M.H.P. Each.	L.P. Ahead. Each.	H.P.C.	I.P.C.
Collars on shaft, number	17	17	8	8
Thickness, inches	¾	¾	¾	¾
Distance between, inches	1 1/16	1 1/16	1 1/16	1 1/16
Outside diameter, inches	17¾	17¾	17¾	17¾
Inside diameter, inches	12½	12½	12½	12½
Number of shoes, top	16	16	7	7
" " bottom	17	17	8	8

SHAFTING

There are four lines of shafting, a pair port and starboard, respectively. Each pair is parallel in itself, but diverges from the center of the vessel and slopes downward aft. The outboard shafts are in two sections each, consisting of one line shaft, supported by a spring-bearing and a propeller shaft, extending through the stern tube and supported by the strut and stern tube bearings. The inboard shafting is in four sections each, there being two line shafts supported by three-spring bearings, one stern tube shaft, carried by the stern tube bearings, and a propeller shaft supported by one strut bearing.

All stern tube and strut bearings are ligum vitae lined and the shafts are composition-bushed at these bearings. The shafting within the stern tubes is covered with a composition casing. The inboard coupling consists of a sleeve secured by four keys to the stern tube shaft. Back of the sleeve is a collar made in halves and secured to the sleeve and to the coupling disk on the line shaft by fitted bolts. The outboard coupling is of the split-sleeve type, consisting of two half sleeves secured to each shaft by two keys; the half sleeves being secured together by bolts.

SHAFT DATA

Line shafts, diameter outside, inches	12⅛
Axial hole, inches	6
Stern tube shafts, diameter outside, inches	12⅜
Axial hole, inches	6
Propeller shafts, diameter outside, inches	12⅜
Axial hole, inches	6
Couplings, diameter, inches	22
Thickness, inches	3
Inboard coupling, diameter of sleeve outside, inches	22½
Inside, inches	14⅛
Length of sleeve, inches	12
Thickness of collars, inches	2⅜
Coupling bolts, number each coupling	8
Diameter (taper)* at face of coupling, inches	2⅜
Outboard coupling, length of half sleeves, inches	48
Bolts securing sleeves, number	16
Diameter, inches	1¾
Spring bearings, diameter, inches	12⅛
Length, inches	18
Forward stern tube bearings, diameter, inches	14⅝
Length, inches	49½
After stern tube bearings, diameter, inches	14⅝
Length, inches	60
Strut bearings, diameter, inches	14⅝
Length, inches	72

* Parallel bolts for inboard coupling.

PROPELLERS

There are four three-bladed propellers, all outboard turning when going ahead. The blades and hubs are of monel metal and cast in one piece. The blades are true-screw machined to pitch.

PROPELLER DATA

Diameter of propeller, inches	110
Hub, inches	27
Pitch, inches	102
Ratio of diameter to pitch	1.08
Area, projected, square inches	5,307
Helicoidal, square inches	5,841
Disk, square inches	9,503
Ratio, projected to disk area	0.56
Helicoidal to disk area	0.61

MAIN CONDENSING APPARATUS

Main Condensers.—There is one main condenser in each engine room of the following principal dimensions:

Inside diameter, feet and inches	10-0
Thickness of shell (steel), inches	½
Length between tube sheets, feet and inches	11-0
Thickness of tube sheets, inches	1
Number of tubes	8,466
Diameter of tubes, inches	⅝
Thickness of tubes, B. W. G.	No. 16
Cooling surface, square feet	15,235
Exhaust nozzle, square feet	48
Diameter of air pump suction, inches	12
Diameter of augmenter suction, inches	15
Diameter of circulating water inlet and outlet, inches	30

Vacuum Augmenter.—In order to obtain the maximum possible vacuum, so essential to efficient operation of turbine

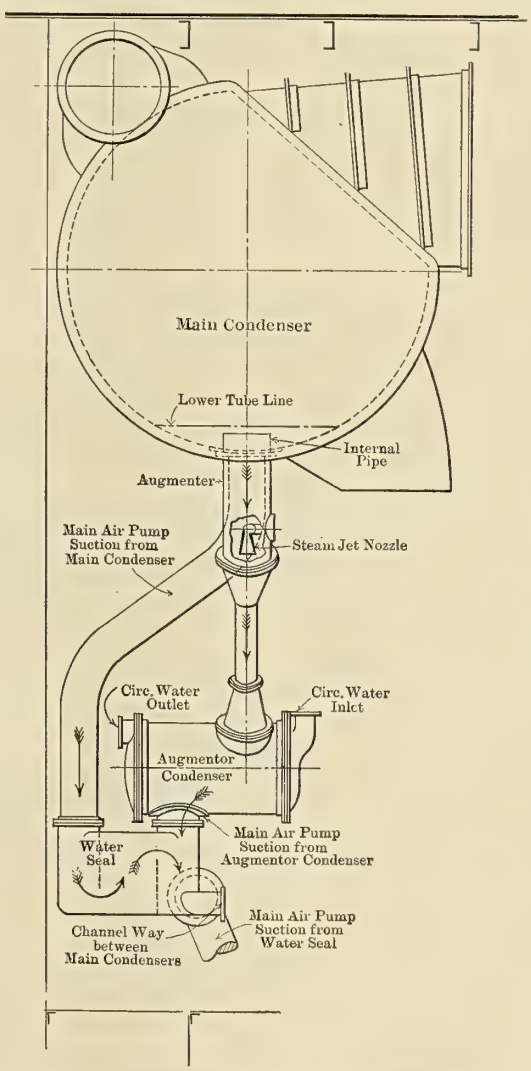


FIG. 3.—ARRANGEMENT OF VACUUM AUGMENTER

machinery, a Parsons vacuum augmenter is installed for each main condenser. It consists of a small condenser of 450 square feet cooling surface, placed below and connected to the main condenser by a pipe having a conical contracted portion,

through which a jet of steam is forced. This pipe extends about 6 inches into the main condenser shell, which prevents the water of condensation from entering it. The steam jet exhausts most of the air and vapor from the condenser and delivers it to the air-pump suction via the augmenter condenser. A water seal is placed in the air-pump suction, between the suction from the augmenter condenser and that from the main condenser, which prevents the air and vapor thus removed from returning to the main condenser. Fig. 3 shows a sketch of this apparatus.

Main Air Pumps.—An air pump, of the M. T. Davidson vertical, twin, bucket, single-acting type, is provided for each main condenser. The steam cylinders are 17½ inches diameter and the water cylinders 35 inches diameter, with a common stroke of 21 inches. The suction nozzle is 12 inches and the discharge nozzle 10 inches.

Main Circulating Pumps and Engines.—There is one centrifugal circulating pump for each main condenser, driven by a compound engine. The principal dimensions of pump and engine are as follows:

Capacity of pump, gallons per minute	15,000
Diameter of suction nozzle, inches (2)	21
Discharge nozzle, inches	30
Impeller, inches	51
H.P. cylinder, inches	11½
L.P. cylinder, inches	23
Stroke, inches	12

Feed and Filter Tank

A feed and filter tank of 4,000 gallons capacity is located at a high level in the forward inboard corner of each engine room. The filter chamber is in the top of the tank and has a capacity of about 700 gallons. The filter has an inner bottom of loose perforated plates and is divided into compartments, in which is placed the filtering material, by vertical division plates. These partitions are so arranged that the water, in passing through the filter, will flow under and over in succession.

Engine Room Auxiliaries

Auxiliary Condensers.—In each engine room there is an M. T. Davidson auxiliary condenser of 720 square feet cooling surface, connected through the auxiliary exhaust pipe to all the auxiliary machinery. Each condenser has an 8-inch by 10-inch by 12-inch by 12-inch horizontal, double-acting, single combined air and circulating pump.

Feed Water Heater.—A feed water heater of the Alberger Condenser Company's type, complete with all the necessary fittings, is located in each engine room. Each heater has a heating surface of 900 square feet. They are of the triple-flow type and located on the discharge side of the main-feed pumps. The heating agent is the exhaust steam, a back pressure being kept on the auxiliary exhaust line for this purpose by means of a spring relief valve at each condenser connection, opening toward the condenser.

Main Feed Pumps.—Two 14½-inch by 9½-inch by 18-inch main-feed pumps of the vertical, double-acting, single type are located on the forward bulkhead in each engine room. The pumps have suctions from the main feed tanks and discharge to the boilers through the feed water heaters or by passing same.

Fire and Bilge Pumps.—Two 12-inch by 10-inch by 18-inch vertical, double-acting, single, fire and bilge pumps are provided in each engine room. They are arranged to draw water from the bilge, drainage system and sea, and discharge to the fire main, sanitary system and overboard.

Pumps for the Forced Lubrication System.—One 8-inch by 7-inch by-8-inch, and two 10-inch by 9-inch by 12-inch, vertical, double-acting, single pumps are provided in each engine room for the forced lubrication system. The former is for circulating cooling water through the oil cooler and the latter for forcing the oil through the system. The oil pressure carried is about 10 pounds per square inch.

Fuel Oil Pumps.—There are two such pumps furnished, one located in each engine room. They are 10-inch by 7-inch by 12-inch, vertical, double-acting, single pumps, arranged to draw oil from the storage tanks and discharge same to the oil burners at the boilers.

Pipe Insulator Pumps.—In each engine room is a 6-inch by 8-inch by 8-inch, vertical, double-acting, single pump for circulating water around the main steam pipe flanges at bulkheads near magazines, to prevent the transmission of heat through the ship's structure to the magazines.

Boilers

The boilers, twelve in number, are of the Babcock & Wilcox watertube type, arranged in batteries of four each in three separate watertight compartments. They are designed to run the entire machinery installation at full power, with an average air pressure in the ash pits of not more than two inches of water. The uptakes are of the usual design and there are two smoke pipes, each about 92 feet in height above the grates and 11 feet 6 inches in diameter.

Boiler Data

Number	12
Working pressure, pounds per square inch	200
Test pressure, pounds per square inch	300
Height to top of drum, feet and inches	13-10¼
Length on floor, feet and inches	9-1½
Width on floor, feet and inches	18-4½
Drum, diameter, inches	42
Length, feet and inches	19-0¾
Thickness, inches	21/32
Number of furnaces, each boiler	1
Number of furnace doors, each boiler	5
Grates, length, feet and inches	7-0
Width, feet and inches	17-0
Total grate surface, square feet	1,428
Total heating surface, square feet	64,234
Ratio G.S. to H.S.	44.98
Number of tube sections, each boiler	31
2-inch tubes, each boiler	1,100
4-inch tubes, each boiler	62
Distance between headers, feet and inches	8-0
Area of each smoke-pipe, mean, square feet	101.56
G.S ÷ area through smoke-pipe	7.03
Kind of forced draft	Closed fire-room
Number of oil burners, each boiler	8

Fuel Oil System

In addition to the usual coal burning appliances, a complete oil-burning system is provided, consisting of the necessary pumps, tanks, oil heaters and piping. Each boiler is fitted with eight oil burners, mechanically atomized, of the Peabody type. This installation is not intended for regular use, but only as an auxiliary to the coal.

Forced Draft Blowers

Four forced draft blowers are installed for each fire room. They are located in specially constructed blower rooms, just below the protective deck and above the center of each fire room. The fans are of the Sirocco type, built by the American Blower Company, and each is driven by a Diehl motor, controlled from the fire room working level or the blower room at will. Air is supplied from the fire room ventilators, which are closed at the bottom when under forced draft. The fan data is as follows:

Revolutions per minute	695
Horsepower, each	40
Fan, diameter, inches	33
Width, inches	30
Number of blades	64

Fire Room Auxiliaries

Auxiliary Feed Pumps.—There are three 14½-inch by 9½-inch by 18-inch auxiliary feed pumps, one in each fire room. They are of the vertical, double-acting, single type and are arranged so that any pump can feed any boiler.

Fire and Bilge Pumps.—In each fire room there is a 12-inch by 10-inch by 18-inch vertical, double-acting, single, fire and bilge pump, arranged to draw water from the bilge, the drainage system and the sea, and discharge to the fire main, the sanitary system and overboard.

Ash Hoists.—There are three ash hoist engines of the two-

cylinder, reversible type, one for each fire room, located in the upper hatch. The ventilators contain the bucket guides, ropes, sheaves, etc. The hoists are operated from the main deck. There are trolleys at this deck for delivering the ash buckets to the chutes at the ship's side.

Ash Expellers.—In addition to the ash hoists, three Stone pneumatic ash expellers are fitted, one in each fire room, discharging the ashes through the vessel's bottom.

Piping System

Main Steam.—The main steam piping is arranged in two symmetrical systems, one on each side of the vessel. The two lines are cross-connected in the forward fire room and in the engine room. The branches from the boilers are 5½ inches

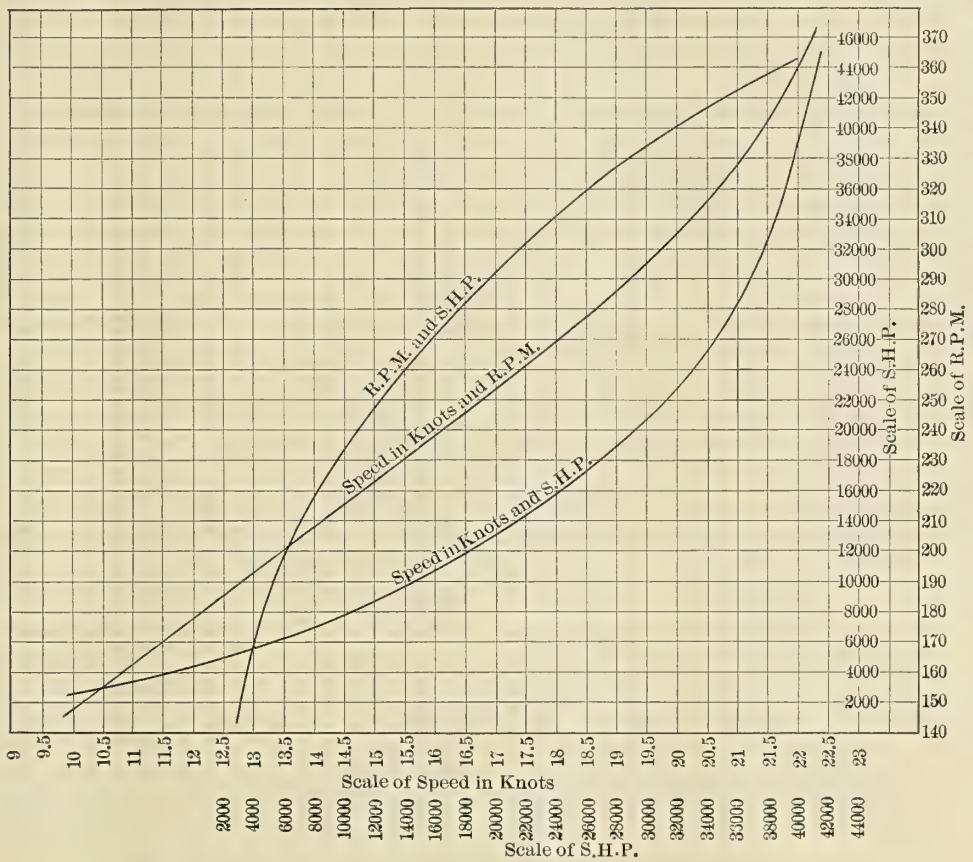


FIG. 4.—SPEED AND POWER CURVES FROM TRIALS OF UNITED STATES BATTLESHIP FLORIDA

diameter each and the lines proper are 7½ inches in the forward fire room, increasing to 9½, 11, 12½ and 14 inches, at each successive boiler connection, the latter size being continued to the turbine regulating valves in the engine rooms.

Auxiliary Steam and Exhaust.—Auxiliary steam and exhaust lines are provided in the machinery space and elsewhere, as required for the various auxiliaries. These systems involve no special features worthy of notice.

Feed and Other Water Piping.—The main and auxiliary feed system, fire and bilge and drainage systems, etc., are installed according to the customary practice, a description of which is quite unnecessary.

Interior Communication

The customary engine and fire room telegraphs, gongs, time fire device, telephones, voice tubes, etc., are fitted for transmitting orders and signalling to the various machinery compartments and other parts of the vessel.

Air Compressor Plant

Located in the engine room are nine 11-inch by 11-inch by 12-inch Westinghouse steam driven air compressors, for use in running pneumatic tools in the engineering department, blowing soot off the boiler tubes and for the gas ejecting system for the guns. Each compressor has a capacity of about 360 cubic feet of free air per minute at 150 pounds pressure. A pneumatic main, independent of the gun gas ejecting system, is led throughout the machinery space, with branches to the workshop, evaporator and dynamo rooms, from which the connections for pneumatic tools are taken.

Evaporating and Distilling Plant

This plant is located on the berth deck, just forward of the engine hatches with the distillers in the port engine hatch at high elvation. There are four evaporators and four distillers with their accessories, arranged to operate in either single or double effect. The plant has a combined capacity of 25,000 gallons of water per 24 hours.

Machine Shop

A well-equipped machine shop is located amidships, between the engine hatches, at the berth deck level. Each machine tool is driven by its own motor.

The following machine tools are installed:

One 24-inch by 48-inch extension-gap lathe.
One 12-inch tool-room lathe.
One 14-inch tool-room lathe.
One 15-inch by 15-inch column shaper.
One 30-inch plain radial drill.
One 16-inch sensitive drill.
One universal milling machine.
One double-emery grinder, wheel 12 inches diameter by 2-inch face.
One portable cylinder-boring machine.

The tools are all up to date and complete, and are provided with the most modern attachments.

There is also a well-equipped blacksmith shop, located on the main deck just abaft turret No. 3.

TABLE I.—STANDARDIZATION TRIAL DATA

Number of run		1	2	3	4	5	6	7	8	9	10
Direction of run		S.	N.	S.	N.	S.	N.	S.	N.	S.	N.
Time on course		4 m. 9.1 s.	5 m. 20.9 s.	4 m. 11.3 s.	6 m. 38.1 s.	5 m. 21.8 s.	7 m. 12.4 s.	3 m. 31.4 s.	4 m. 10.1 s.	3 m. 36 s.	3 m. 18.8 s.
Revolutions of main engines:											
To make one knot—mean of 4 shafts		798.23	996.57	802.23	994.58	787.08	1,020.68	823.95	958.63	849.65	936.75
Per minute	Shaft No. 1	176.85	170.86	175.61	137.68	134.52	128.89	223.84	219.13	225.48	269.86
	Shaft No. 2	213.37	207.10	212.01	165.41	161.20	156.05	268.49	266.04	271.09	324.88
	Shaft No. 3	203.83	198.47	204.16	160.04	157.81	153.39	221.39	217.92	224.37	268.11
	Shaft No. 4	175.16	169.14	174.36	136.40	133.55	128.50	221.46	217.42	223.51	268.30
Average per minute		192.30	186.39	191.54	149.88	146.77	141.71	233.80	230.13	236.11	282.79
Speed in knots		14.452	11.218	14.325	9.043	11.187	8.326	17.029	14.394	16.667	18.109
Horsepowers:											
S. H. P.	Shaft No. 1	849	803	834	434	377	361	1,813	1,830	1,894	3,387
	Shaft No. 2	2,240	2,133	2,163	1,125	999	983	4,457	4,549	4,609	8,187
	Shaft No. 3	1,569	1,568	1,592	800	710	698	1,722	1,754	1,795	3,351
	Shaft No. 4	788	744	767	396	374	347	1,750	1,739	1,810	3,354
Total S. H. P.		5,446	5,248	5,356	2,755	2,460	2,389	9,742	9,872	10,108	18,279
I. H. P. auxiliaries		670	670	652	685	637	603	755	746	723	872
Total S. H. P. and I. H. P.		6,116	5,918	6,008	3,440	3,097	2,992	10,497	10,618	10,831	19,151
Steam pressure:											
Gage	Main steam P	210	210	203	215	215	208	210	220	212	205
	Main steam S	205	207	200	210	210	205	203	214	205	193
Absolute	At M.H.P. turbines P	17	15	18	11 5	10	10	37	35	37	65
	At M.H.P. turbines S	20	20	20	15	14	14	43	40	45	70
	At H. P. C. turbine	125	125	127	80	73	72	5	9	12	10.5
	At I. C. P. turbine	50	55	58	35	31	30	115	110	116	188
	At L. P. turbines P	2.5	2.5	2	1.5	1.5	1.5	5	5	5.5	6
	At L. P. turbines S	9.5	9.5	9.5	9	8.75	8.75	10.5	10.25	10.5	12
Vacuum in inches	P	29.1	29.2	29.2	29.3	29.3	29.3	28.8	29	28.9	28.7
Vacuum in inches	S	29.1	29.1	29.1	29.1	29.2	29.2	29.1	29.2	29.2	28.9
Number of turbines in operation		6	6	6	6	6	6	5	5	5	5

Number of run		11	12	15	16	17	18	19	20	21	22
Direction of run		S.	N.	S.	N.	S.	N.	S.	N.	S.	N.
Time on course		3 m. 4.7 s.	3 m. 17.9 s.	2 m. 41.6 s.	2 m. 49.5 s	2 m. 39.7 s.	2 m. 45.9 s.	2 m. 40.8 s.	2 m. 57.8 s.	2 m. 49.7 s.	3 m. 0.7 s.
Revolutions of main engines:											
To make one knot—mean of 4 shafts		872.75	931.68	961.20	1,003.90	965.28	991.45	960.75	946.50	904.30	954.25
Per minute	Shaft No. 1	271.02	270.15	358.43	357.75	363.29	358.92	361.74	318.83	320.25	317.34
	Shaft No. 2	325.43	324.03	354.53	351.17	359.40	353.57	354.72	314.09	315.62	311.88
	Shaft No. 3	269.49	267.44	357.29	355.82	364.04	360.54	358.10	321.87	323.71	321.34
	Shaft No. 4	269.02	268.82	357.24	357.52	363.85	360.38	359.80	322.44	319.72	317.17
Average per minute		283.74	282.61	356.87	355.57	362.65	358.35	358.59	319.31	319.83	316.93
Speed in knots		19.491	18.191	22.277	21.239	22.542	21.700	22.388	20.247	21.214	19.923
Horsepowers:											
S. H. P.	Shaft No. 1	3,388	3,390	9,054	9,087	9,504	9,282	9,532	5,994	6,155	6,080
	Shaft No. 2	8,168	8,198	9,572	9,692	9,668	9,652	9,507	6,502	6,470	6,394
	Shaft No. 3	3,379	3,338	8,128	9,678	10,219	10,023	9,590	7,172	6,974	6,963
	Shaft No. 4	3,336	3,387	9,324	9,546	9,860	9,658	9,355	6,803	6,286	6,236
Total S. H. P.		18,271	18,313	36,078	38,003	39,251	38,615	37,984	26,471	25,885	25,673
I. H. P. auxiliaries		859	875	1,210	1,261	1,252	1,229	1,228	1,153	1,101	1,122
Total S. H. P. and I. H. P.		19,130	19,188	37,288	39,264	40,503	39,844	39,212	27,624	26,986	26,795
Steam pressure:											
Gage	Main steam P	213	211	185	185	187	180	176	185	185	185
	Main steam S	204	200	187	184	187	182	175	187	185	185
Absolute	At M.H.P. turbines P	65	65	152	160	168	160	163	168	112	110
	At M.H.P. turbines S	70	70	160	160	165	165	168	115	115	115
	At H P. C. turbine	8	7.5	12.5	8	8	10	10	10	8	8
	At I. C. P. turbine	189	188	13.75	13.75	13.75	13.75	13.75	13.75	13.5	13.5
	At L. P. turbines P	8.5	8.5	15	18	18.5	17	17.5	18	13.5	14.5
	At L. P. turbines S	12	12	17	17	18	17.5	18	13.75	13.75	13.75
Vacuum in inches	P	28.7	28.6	28	27.8	27.7	27.8	27.8	27.8	28.2	28.2
Vacuum in inches	S	29	29	28.1	28.2	28.2	28.1	28	28.5	28.7	28.7
Number of turbines in operation		5	5	4	4	4	4	4	4	4	4

Electric Plant

There is one dynamo room located forward of the forward boiler room, and two distribution rooms, one forward and one aft, in which are located the lighting and power distribution boards for the respective parts of the ship. The forward distribution room also contains the generator boards.

The generator installation consists of four six-pole, compound-wound, 300-kilowatt General Electric generators, each driven by a two-stage horizontal Curtis turbine. Each generator will deliver at normal load 2,400 amperes of current at 125 volts when running at 1,500 revolutions per minute. The generators are capable of delivering ⅓-overload for two hours without injury.

There are two condensers of elliptical section for the exclusive use of the dynamo turbines. Each condenser has its independent air pump, centrifugal circulating pump and hotwell tank and pump. The exhaust piping is so arranged with cutout valves that either or both condensers can be used on any or all the generator sets.

The condensers are of the following principal dimensions:

Horizontal diameter inside shell, feet and inches	4-0
Vertical diameter inside shell, feet and inches	5-8¾
Thickness of shell, inches	¼
Length between tube sheets, feet and inches	6-8½
Thickness of tube sheets, inches	1
Number of tubes	2,190
Diameter of tubes, inches	⅝
Thickness of tubes, B.W.G.	16
Diameter exhaust nozzle, inches	28
Air-pump suction, inches	7
Circulating water inlet and outlet, inches	9
Cooling surface, square feet	2,403

TABLE II.—OFFICIAL TRIAL DATA

	4-Hour Full Power Trial.	24-Hour, 19-Knot Endurance Trial.		24-Hour 12-Knot Endurance Trial.
Speed in knots	22.08	19.19		12.08
Slip of propellers, percent of own speed, mean	27.67	20.98		19.32
Draft, mean on trial, feet and inches	27–10	27–9 41/64		27–6 21/64
Displacement, corresponding, tons	21,240	21,215		20,976
Number of turbines used	4	5 first 5 hours	4 last 19 hours	6
Number of boilers used	12	12		8
Grate surface used, square feet	1,428	1,428		952
Heating surface used, square feet	64,236	64,236		42,824
Pressures (average):				
Main steam—				
At boilers, pounds (gage)	210	202		203
Engine rooms, pounds (gage)	179.2	189.1		197.4
		5-turbine comb.	4-turbine comb.	
In steam belt—				
H. P. C. turbine, pounds (absolute)	10.8	9.3	9.2	114.4
I. P. C. turbine, pounds (absolute)	13.7	178	12.2	49.7
M. H. P. turbines, pounds (absolute)	173.1	73.6	87.6	17.2
L. P. turbines, pounds (absolute)	18.5	10	11.5	5
Barometer, inches of mercury	30.2	30.17	30.14	30.04
Vacuum in condensers, inches of mercury	28.4	28.9	28.5	29.6
Main feed line, at pumps, pounds (gage)	278	268.7		265.8
Auxiliary exhaust in feed heater, pounds (gage)	6.7	4.9		6.4
Forced lubrication system, pounds (gage)	13.3	12.6		11.1
Air pressure in fire rooms, inches of water	1.99	0.6		0
Temperatures, degrees F. (average):				
Main injection	39.8	52		45
Main overboard discharge	64.1	67.7		52.8
Feed water	197.8	201		223.3
Engine rooms, working platform	81.8	98.5		94.6
Fire rooms, working level	79	98		100
Outside air	31	53.2		53.4
Smoke pipes	620	536		381
Revolutions or double strokes per minute (average):				
Shaft No. 1	366.64	289.59		165.65
Shaft No. 2	361.24	293.68		195.45
Shaft No. 3	363.62	285.43		188.66
Shaft No. 4	364.11	289.32		164.29
Mean, all shafts	363.90	289.50		178.51
Main air pumps	23.5	18.8		17.3
Main circulating pumps	244.3	201.3		161.8
Main feed pumps	26.3	20.6		16.8
Forced draft blowers	712	573		Not used
Horsepower (average):				
Shaft No. 1, S. H. P.	10,039	4,488		646
Shaft No. 2, S. H. P.	10,370	5,281		1,583
Shaft No. 3, S. H. P.	10,148	4,710		1,415
Shaft No. 4, S. H. P.	9,954	4,880		789
Total S. H. P., all shafts	40,511	19,359		4,433
I. H. P. main air pumps	29	21		10
I. H. P. main circulating pumps	507	315		167
I. H. P. main feed pumps	129	99		41
I. H. P. chargeable to forced draft blowers	333	178		Not used
I. H. P. other auxiliaries	301	250		246
Total I. H. P., all auxiliaries	1,299	863		464
Total horsepower all machinery	41,810	20,222		4,897
Water consumption data:				
Pounds per hour—				
Main engines	493428	251,669		74,543
Auxiliaries	67,352	56,382		41,843
All machinery	560880	308,051		116386
Main engines, per S. H. P.	12.180	(*a*)13.000		16.815
Auxiliaries, per I. H. P.	51.849	65.333		90.179
All machinery, per total, H.P.	13.415	(*b*)15.233		23.767
All machinery, per S. H. P.	13.845	(*c*)15.913		26.254
Coal consumption data:				
Kind and quality	George's Creek, very good	Good		Good
B. T. U. per pound	No sample taken	No sample taken		No sample taken
Pounds per hour	66,586	34,720		10,920
Per S. H. P.	1.644	1.793		2.463
Per total H. P.	1.593	1.717		2.23
Per square foot of grate	46.629	24.314		11.471
Miscellaneous:				
S. H. P. per square foot of grate	28.369	13.557		4.657
Square foot of heating surface per S. H. P.	1.586	3.318		9.660
Square foot of cooling surface (main condensers) per S. H. P.	0.752	1.574		6.873
Pounds of water evaporated per pound of coal per hour	8.423	8.872		10.658
Knots per ton of coal	0.743	1.238		2.478

(*a*), (*b*) and (*c*) are averages for entire trial. For 5-turbine combination, first 5 hours of trial, (*a*) = 12.736, (*b*) = 14.995 and (*c*) = 15.668. For 4-turbine combination, last 19 hours of trial, (*a*) = 13.074, (*b*) = 15.301 and (*c*) = 15.982.

REFRIGERATING PLANT

There are four Allen dense air ice machines, each capable of producing the cooling effect of three tons of ice per day. One machine is located forward, primarily for cooling the forward magazines, but can be used on the cold-storage system if desired. The other machines are located aft the engine room hatches and are fitted for cold-storage service, ice making, etc., and for the midship and after magazines cooling systems. There are five refrigerating rooms, isolated by air locks and insulated with cork in the usual manner.

TORSION METERS

Each line of shafting is fitted with a Gary-Cummings torsion meter for ascertaining the shaft horsepower of the main turbines. This instrument, invented by Mr. H. R. Gary, late of the Bureau of Steam Engineering, U. S. N., and developed by Mr. H. H. Cummings, of the Cummings Ship Instrument Works of Boston, is designed to meet the specifications of the Navy Department, which require recording torsion meters. It is simple in construction, accurate in operation and gave satisfactory and consistent results on the trials.

In brief, the instrument as installed consists of a steel tube about fourteen feet long, placed within the axial hole of a section of line shaft in each line of shafting. One end of this tube is securely fastened to the shaft and the other end is supported near the shaft coupling by a ball bearing, hence being free to turn with reference to the shaft as the shaft twists under load. To this end of the tube is secured an arm at right angles to it, and extending radially through a slot out in the face of the coupling disk to the periphery. On the outer end of this arm and external to the shaft is attached a mechanism that actuates two marking points. It is evident that any twist in the shaft, as it rotates under load, will produce a slight turning movement between the shaft and the free end of the tube. This movement is transmitted through the arm to the marking points, which trace two short parallel lines on a card, the card being held in a frame supported independent of the shaft, that is brought into contact with the points only when it is desired to measure the torque of the shaft. The distance between the lines thus marked on the card, measured to proper scale, is a factor of the amount of torque developed in the shaft, from which the shaft horsepower is readily figured.

TRIALS

Four trials were required of the *Florida* as follows:

1. A progressive trial over a measured mile water course for standardizing the screws, extending from maximum down to about ten knots speed.

This trial, generally called the standarization trial, was run on the Rockland course Monday, March 25, 1912. The weather was clear with a brisk wind blowing almost parallel to the course. The first run was commenced about 6:30 A. M. in a southerly direction, the runs being alternately south and north. In all twenty-two runs were made over the measured mile at various speeds, but the data from only twenty runs was used in compiling the speed and power curves, runs Nos. 13 and 14 not being up to the speed desired, were thrown out. At the conclusion of the trial the *Florida* returned to anchor off the Rockland breakwater to prepare for the full power trial next day.

From the data obtained it was found to require 321.4 revolutions per minute of the main engines to attain the designed speed of 20.75 knots, 286.3 revolutions for 19 knots and 177.2 revolutions for 12 knots. Table 1 contains the data obtained on the various runs, from which the curves, Fig. 4, were plotted.

2. A full-speed trial of four hours' duration in the open sea at the highest speed obtainable, with an average air pressure in the ash pits not exceeding 2 inches of water and not over 185 pounds steam pressure at the main high-pressure turbines. The average speed to be at least 20.75 knots and the water consumption guarantee being 15 pounds per hour for

main engines and auxiliaries per shaft-horsepower of the main turbines.

This trial took place at sea off Rockland, Me., on Tuesday afternoon, March 26, 1912. The weather was clear, with gentle breezes and smooth sea. The designed speed was easily exceeded, an average speed of 22.08 knots being attained, which set a new record in the navy for battleships, and the guaranteed water rate was likewise bettered. Table II. gives a comparative list of the data obtained on this and the following trials.

3. An endurance and water and coal consumption trial in the open sea of twenty-four hours' duration at as nearly a uniform speed of 19 knots as possible. The average not to fall below that figure. The water consumption guarantee was 16.25 pounds on the same basis as the preceding trial.

The trial was started at 1:20 A. M., March 27, 1912, and terminated at the same hour on the following day. The weather was clear with light airs and a smooth sea. Unfortunately, unsatisfactory dummy clearances developed in the starboard low-pressure turbine, which rendered it necessary to disconnect the intermediate-pressure cruising turbine after five hours' running, and to proceed with the trial on the four-turbine combination, but in spite of this handicap the water consumption was within the guarantee. For data see Table II.

4. An endurance and water and coal consumption trial at 12 knots, under similar conditions to the preceding trial, the water consumption guarantee being 26 pounds on the same basis as before.

At 4:20 A. M., March 28, 1912, the trial commenced. The weather was excellent throughout the trial, there being no wind and a smooth sea. The water consumption on this trial was a little in excess of the guarantee, due to the high consumption of the auxiliaries. The data obtained on this trial is also given in Table II.

The conduct and result of all the trials was most satisfactory, and reflects much credit not only on the navy yard force, where the vessel was constructed, but particularly the ship's engineering force, to whose organization, skill and energy, displayed in handling the machinery throughout the trials, the success was largly due.

Foundering of the Titanic

While traveling at full speed on her maiden trip from Southampton to New York at 11:40 P. M. (ship's time), Sunday, April 14, the new White Star steamship *Titanic* of 45,000 gross tons collided with an iceberg at a point west longitude 50° 14′, north latitude 41° 46′, or about 1,150 miles east of New York. Less than three hours later the ship sank, carrying with her all on board except about 700 persons who were taken off in lifeboats and later picked up by the *Carpathia* of the Cunard Line. As the total number of persons on board the *Titanic* was 2,340, including officers and crew, the loss of life was about 1,600. The vessel was certified by the British Board of Trade to carry over 3,300 persons, but the certificate provided for only sufficient lifeboats to carry 950 persons.

Accurate information as to just what occurred on board the ship when she was struck and before she sank probably will never be known, for all the engineers and officers, except those whose duty it was to man the lifeboats, died bravely at their work. After sifting the great mass of contradictory and unwittingly distorted evidence offered by the survivors up to date, it seems that the ship was steaming at a speed of about 21 knots; the night was clear and no indications of ice had been detected, although warning of the presence of icebergs in that vicinity had been received by wireless. Just before the collision occurred an iceberg dead ahead was reported to the bridge from the crow's nest, and the course of the ship was changed to avoid a collision. The warning had come too late, however, and the vessel was struck by the submerged part of the iceberg on the starboard bow at about the position of the foremast. As only a slight jar was felt in the ship the blow was probably a glancing one, but as the helm had been thrown over and the stern swung to starboard, the momentum of the vessel probably caused the side of the ship to scrape along the submerged part of the iceberg, piercing her shell plating in several places from the second or third watertight bulkheads back into the boiler rooms, and thus flooding the forward holds. Some reports also indicate that the engine room began to fill.

A complete description of the *Titanic* and her sister ship the *Olympic* will be found in the December, 1910, June, 1911, and July, 1911, issues of INTERNATIONAL MARINE ENGINEERING. Further particulars of the general arrangement of the ship can be seen from the drawings which we reproduce herewith from *The Shipbuilder*.

Apparently the first compartment to be filled was that containing the mail room (shown on the orlop deck plan, Fig. 1); that is, the compartment between watertight bulkheads 3 and 4. Probably the compartment forward of that was also filled, and, as the stokers came on deck immediately after the collision, reporting that some of the boiler rooms were filling, it is evident that at least three of the watertight compartments began to fill at the start; and as this changed the trim of the vessel, partially submerging the bow, it is also probable that some of the other watertight bulkheads, through leakage and the excessive stresses occasioned by the flooding of the compartments, opened up and admitted water to other parts of the vessel until the forward part of the bulkhead deck was submerged, causing the ship to sink.

Whenever two adjacent compartments in the hull of a large passenger steamship like the *Titanic* are flooded the ship is in a dangerous condition, and if a third compartment should be filled the situation is critical. If the damage filled the ship is practically doomed to sink. If the damage due to a collision is confined to two compartments and the bulkheads hold and remain practically watertight, there will be sufficient reserve buoyancy to keep the ship afloat. Even a third compartment might be filled and still the ship would float, provided the flooded compartments were not adjacent.

The sub-division of the *Titanic* consists of: First, the cellular double bottom, which extends the full length of the ship from the stem to the stern. This is 5 feet 3 inches deep, and is increased to 6 feet 3 inches depth in the engine room. Besides the center keelson and a continuous longitudinal on each side 30 feet from the center line, there were five intercostal tank girders amidships on each side of the center keelson, and additional girders are fitted under the engine-rooms.

From the double bottom to the upper deck, as shown in Fig. 1, the hull is divided transversely by fifteen transverse watertight bulkheads. Aft of the forward collision bulkhead there are three cargo holds, each 50 feet long. The bulkheads in the

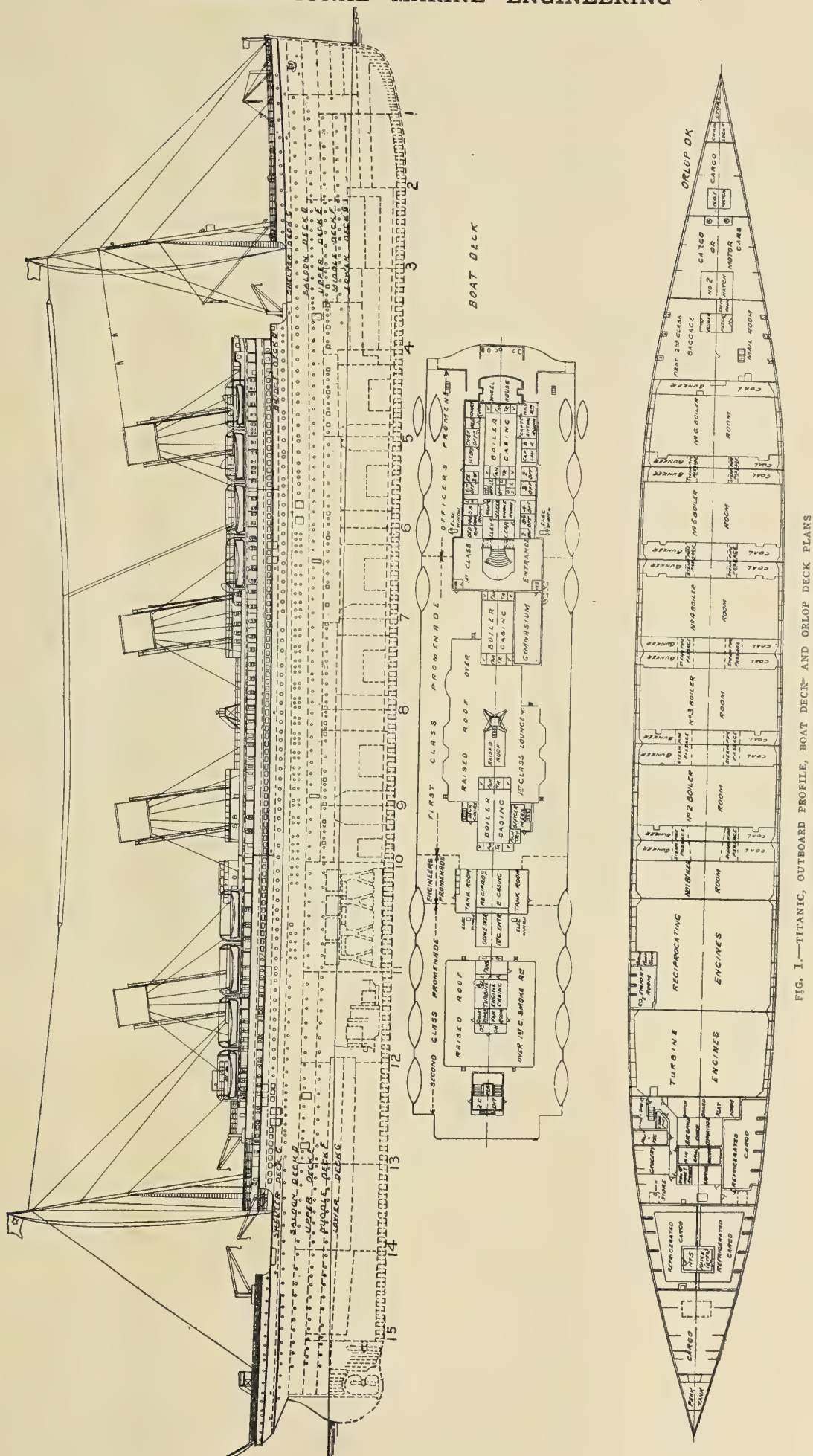


FIG. 1.—TITANIC, OUTBOARD PROFILE, BOAT DECK AND ORLOP DECK PLANS

holds are further reinforced by the steel decks, as shown in Fig. 1. Abaft the forward cargo holds are six boiler rooms, each of which, except the after one, which is nearest the engine room, is 57 feet long. The twenty-nine boilers are arranged side by side athwartships, five in each boiler room, as shown in Fig. 2.

The coal bunkers are arranged athwartships between the boiler rooms, and the watertight bulkheads which separate the

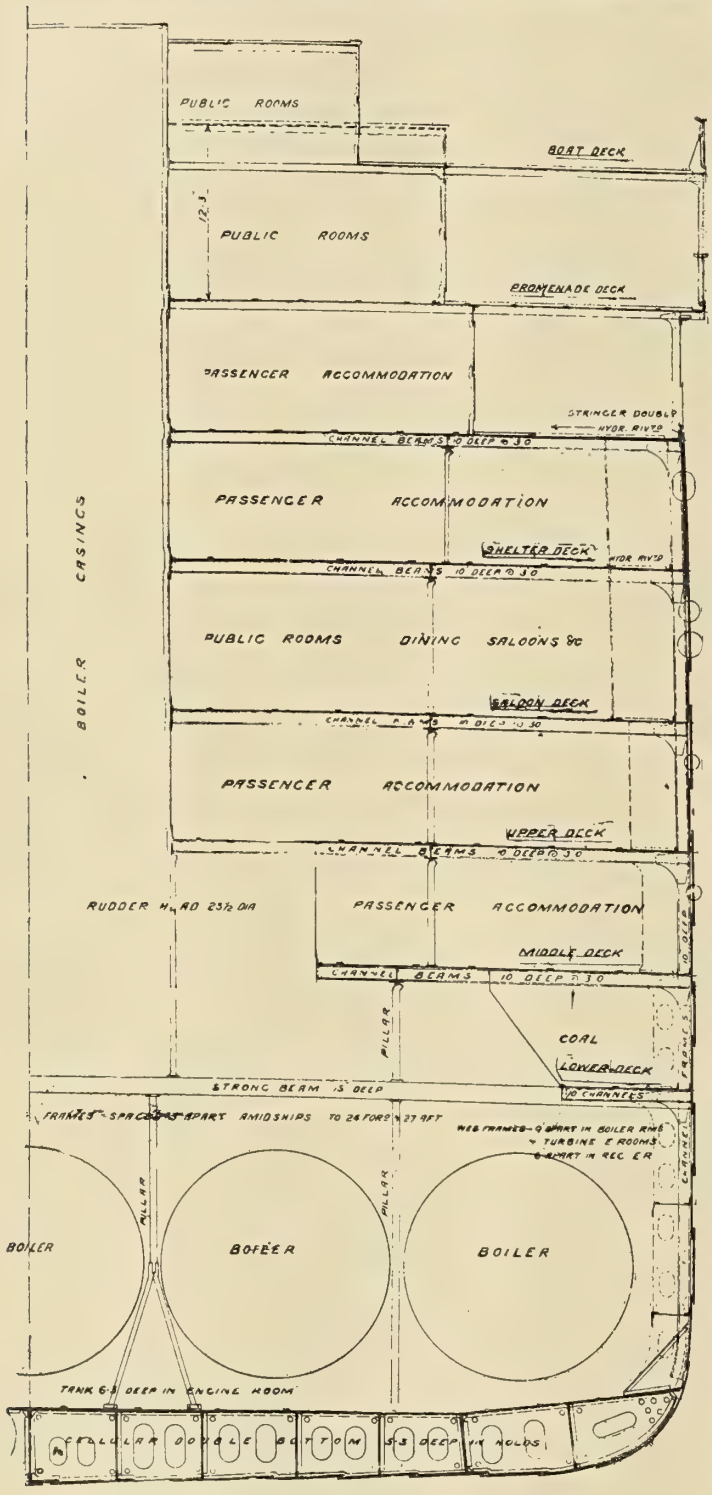


FIG. 2.—TITANIC, SECTION THROUGH BOILER ROOM

boiler rooms are located in the center of the bunkers, being stepped in way of the up-takes. Passageway is provided for between the boiler rooms through alleyways, where the watertight bulkheads are carried to the coal bunker bulkheads, and there are located the watertight doors, which can be automatically closed from the bridge.

Abaft the boiler space is the largest compartment in the ship, which is the reciprocating engine room, about 69 feet long. Abaft this is the turbine engine room, 54 feet long. Aft the machinery space are two other cargo holds. Most of the auxiliary machinery, including condensers and pumps, is located in the main engine rooms, but in the compartment aft the turbine room are the principal electric generating sets. There are also two 30-kilowatt auxiliary sets, situated on a platform in the engine casing at the saloon deck level, well above the waterline, so that in the event of flooding the main electric plant, lighting and power could be obtained from the auxiliary plant, a circumstance which probably accounts for the fact that the ship was kept lighted until she sank.

The sub-division of the part of the ship forward of the boiler space, where it is expected that most of the damage from a collision would occur, is reinforced in addition to the ordinary frames and bulkheads by longitudinal girders at each deck level; the transverse deck beams, which are of channel section 10 inches deep, are placed according to the spacing of the frames and secured thereto by efficient brackets. At the deck levels there are four longitudinal girders which extend the whole length of the ship, except in the machinery space, where special girders are provided of a sectional area equivalent to the four girders in the other parts of the ship. These girders are suitably supported by stanchions and columns. Thus these longitudinal girders, besides supporting the decks, furnished support against deflection of the transverse watertight bulkheads which separate the compartments.

The fifteen transverse watertight bulkheads extend from the double bottom to the upper deck at the forward end of the ship, and from the double bottom to the saloon deck at the after end of the ship, so that all the bulkheads extend far above the load waterline and give a considerable margin for the emersion of the ship by the flooding of a limited number of the compartments. It is evident, therefore, that the hull structure of the *Titanic* was of exceptional strength.

Without further information, however, regarding the scantlings of the hull and without definite information concerning just which compartments were filled directly by the piercing of the skin of the ship, or by leakage through the transverse bulkheads, and with no knowledge of the rate at which the compartments were filled or the effectiveness of the pumps and the bulkhead deck, no accurate assumption can be made as to the longitudinal bending stresses or the shearing stresses at any section of the hull. The first reports from the survivors even indicated that there was a breakage or partial rupture, or bending of the hull, at a point aft of the 'midship section. Such an occurrence has taken place on at least three steel ships which foundered, but in those cases the ratios of breadth and depth to length were abnormal. In modern ship design the maximum shearing and longitudinal stresses are proportioned for cases as extreme, if not more extreme, than that in which the *Titanic* was placed, although the *Titanic* was in about the worst condition as far as the stresses are concerned that a ship can be placed.

The effectiveness of the watertight bulkheads is also doubtful. Their absolute tightness might very well be questioned, but from the nature of the design of the *Titanic*, unless the load due to the water pressure in the flooded compartments was augmented by the weight of the contents of the holds brought upon the bulkheads by the inclination of the ship just before she finally sank, there is every reason to suppose that they held and maintained the structure intact.

A matter of vital importance in a disaster like this is the equipment of life-saving apparatus. Inadequate as it was on the *Titanic* it is gratifying to find that, in spite of the fact that the lifeboats were partly in charge of inexperienced men, yet it was possible to launch all safely regardless of the inclination of the vessel.

Old American Coasting and Sound Steamers—Part II

BY FRANCIS B. C. BRADLEE

The first steamboat worthy of the name to ply on the coast of Maine was the *Patent*. She is described as follows by the Portland *Argus* of July 8, 1824:

"The steamboat *Patent*, Capt. Seward Porter, arrived here yesterday, in four days from New York, having touched at a number of places to land passengers. Her engine has been proved to be of superior workmanship and propels the boat about 10 miles an hour."

In a report made to the stockholders she is described as of 200 tons and as costing $20,000 (£4,110). She had one mast and a staff at her stern, from which was displayed the Stars and Stripes. The *Patent* was low and without a hurricane deck; her boiler and engine were below, and she had a heavy balance wheel half above the deck, and an arrangement by which the paddle-wheels could be disconnected. Her cabins were all below. The quarter deck was clear, with seats all round it. In the Boston *Courier* of Aug. 12, 1824, her arrival from Portland on the 8th is noticed, stating that she brought seventeen passengers and made the trip in 17½ hours against a head wind (distance 110 miles).

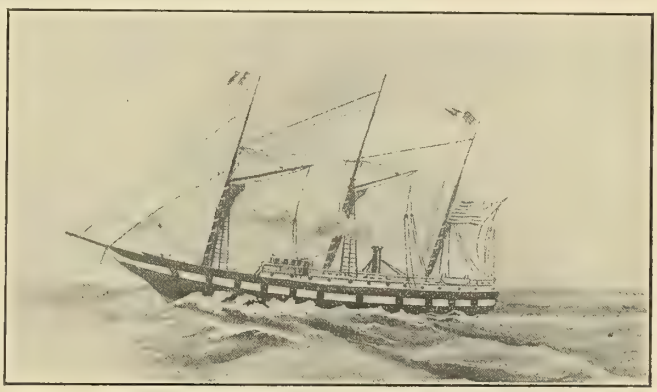
Several small steamboats followed the advent of the *Patent*, and by 1826 what was known as a "steam brig," called the

STEAM BRIG NEW YORK, BUILT IN 1822. ONE OF THE EARLIEST SEA-GOING STEAMERS IN THE UNITED STATES
(From a negative in the author's collection)

New York, built in New York in 1822, was running on the coast. She was owned by a Mr. Bartlett, of Eastport, Me., who fitted her with new machinery and ran her regularly between Boston, Portland, Eastport and other ports on the coast. In 1829 the *New York*, while on her way to Eastport, caught fire when about 8 miles to the eastward of Petit Menan Light, and burned to the water's edge. Luckily there was no loss of life. One reason for the fire spreading so rapidly was "that no fire engine, hose or buckets could be found on board." This throws light on the way some of the early steamboats were managed. The *New York* had full, round lines, flush deck, long scroll head, like the packet ships of that day, her name painted on the paddle boxes, with the addition New York and Norfolk packet. In 1832 the *Chancellor Livingston*, that had for years run on the Hudson River and Long Island Sound, was sold to Cornelius Vanderbilt, who placed her on the Boston-Portland route. She was 496 tons, 157 feet long, 33 feet beam, 10 feet depth, with a "cross-head" engine having a 56-inch cylinder with 6-foot stroke. The *Chancellor Livingston* was considered much superior to any of the other Maine coast steamboats of that time, and was in use until 1834, when, showing signs of wear, a new steamer called the *Portland* (163 feet by 27 feet by 11 feet) was built to take her place, the engine from the *Livingston* being transferred to her. The *Portland* was very successful, being in use as late as 1850.

During this early period there were many steamers on the Maine coast that ran there for short periods only, being sold or transferred to other routes, and these not coming within the scope of this article we shall not mention them. In 1833 the Boston & Bangor Steamship Company started with a wooden side-wheel boat called the *Bangor*, built in New York by Brown & Bell. She was about 160 feet long, and had a "cross-head" engine with a cylinder 36 inches in diameter, 9 feet stroke. This vessel was sold to the Turkish Government in 1842, and sent across the Atlantic to Constantinople. (See the article on Old American Transatlantic Steam Liners.)

In 1845 the Bangor Steamship Company brought forward a most curious and famous steamer. She was also called the *Bangor*, and is memorable as being the first iron and screw propelled seagoing craft in the United States. The hull and



COAST OF MAINE SCREW STEAMER BANGOR OF 1845
(From a painting in the author's possession)

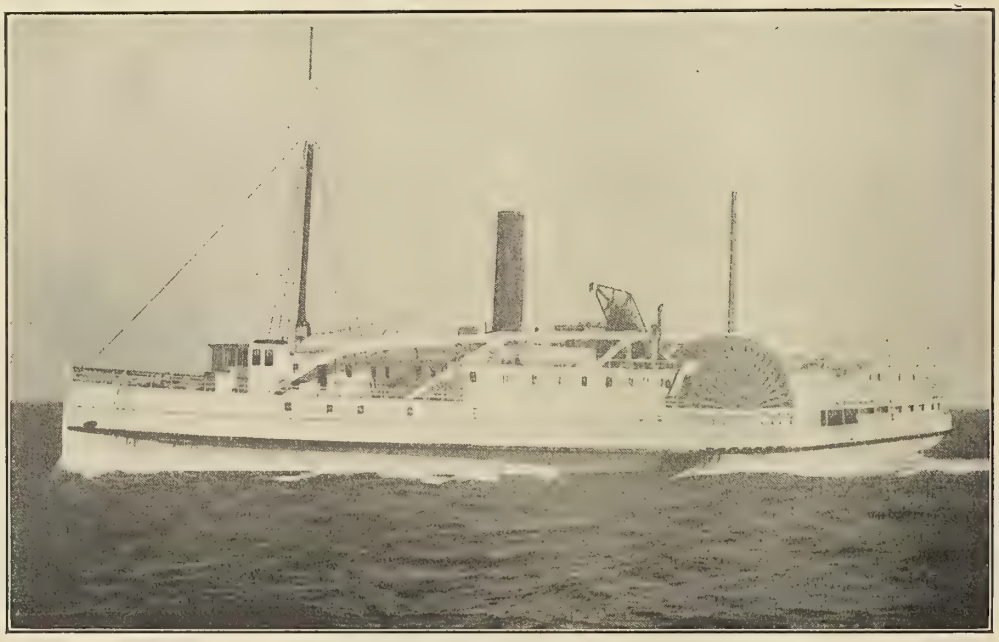
machinery (begun in 1843 and not finished until 1845) were constructed by Betts, Harlan & Hollingsworth, at Wilmington, Del., the tonnage of the *Bangor* being 231; length, 120 feet; breadth, 23 feet; depth of hold, 9 feet. The engines were what was known as the "Loper" type, consisting of two independent cylinders, each 22 inches in diameter by 24 inches stroke of piston; the boiler was of iron, of the drop-flue type, 20 feet in length, and there were twin-screw propellers, each 8½ feet in diameter. The *Bangor* made 15.7 statute miles on her trial trip, but on Aug. 31, 1845, soon after beginning her regular trips, she was burned off the Maine coast, but was rebuilt, and again placed on the Boston and Bangor route. In December, 1846, she was purchased by the United States Government, renamed the *Scourge*, and used as man-of-war during the Mexican War. She was afterwards sold to persons in Louisiana.

In the 50's the best-known Bangor boats were the *Penobscot* and *Boston*, belonging to Sanford's Independent Line, and the *Daniel Webster*, owned by the Boston & Bangor Steamship Company. These boats varied in length from 220 to 240 feet, and had beam engines with cylinders 48 to 52 inches in diameter by 11 feet stroke. The *Daniel Webster* was considered the finest of these three steamers, and ran mostly

between Portland and Bangor in connection with what was known as the "steamboat train" to and from Boston on the Eastern Railroad.

In 1863 the Bangor Line had constructed by John Englis & Son, New York, the *Katahdin,* 1,234 tons gross, 241 feet by 34 feet by 12 feet, with a beam engine having a 50-inch cylinder by 11 feet stroke; and in 1867 the same builders constructed the *Cambridge,* 1,327 tons gross, 250 feet long, 38 feet beam, 13 feet depth of hold, with a beam engine having one cylinder 60 inches in diameter by 11 feet stroke. The latter vessel ran ashore on Georges Island, coast of Maine, Feb. 10, 1886, and became a total loss, and the *Katahdin* was broken up for old junk about 1895.

In 1843 the various steamers running to Portland were consolidated into one concern known as the Portland Steam



COAST OF MAINE STEAMBOAT FOREST CITY, 1854
(Negative from N. L. Stebbins)

Packet Company. Their first steamers were two wooden propellers, the *Commodore Preble* and the *General Warren,* each boat being 150 feet long, 24 feet beam, 8 feet depth of hold, and having high-pressure engines with two cylinders each 18 inches in diameter by 24 inches stroke. At the time of the discovery of gold in California in 1849 these two steamers were sold for service on that coast, and sent round via Cape Horn, being nine months on the voyage.

For some reason or other, probably because of their small passenger accommodation, propellers were not popular at first on the coastwise route, so the Portland Line soon replaced the *Commodore Preble* and *General Warren* by side-wheel boats named the *Atlantic* and *St. Lawrence.* These were followed by the *Forest City* in 1854, the *Lewiston* in 1856, and the *Montreal* in 1857, wooden side-wheelers, about 235 feet long and 33 feet beam, with beam engines having 52-inch cylinders by 11 feet stroke. The *Lewiston* was afterwards sold to the Portland, Bar Harbor & Machias Steamboat Company, and in 1867 the *John Brooks* was bought, a wooden side-wheeler, 250 feet long, 34 feet beam, with the usual beam engine; she had previously run on Long Island Sound. After her followed the *Tremont* (1883), and the ill-fated *Portland* in 1890, still wooden paddle-wheel steamers, and it was not until 1900 that the Portland Steam Packet Company had a modern steel propeller steamer built, which was called the *Governor Dingley.*

(To be concluded)

Launching of the U. S. Destroyer Henley

The torpedo boat destroyer *Henley* was launched at the works of the Fore River Shipbuilding Company, Quincy, Mass., April 3. The principal dimensions of the vessel are as follows:

Length between perpendiculars.....	289 feet.
Length over all.....	293 feet 10½ inches.
Breadth, molded	26 feet 4½ inches.
Trial displacement	742 tons.
Trial draft	8 feet 4 inches.

Battery—Five 3-inch guns, three 45 c/m torpedo tubes on deck, two .30-caliber automatic guns.

The contract was signed on Nov. 28, 1910, and calls for delivery on Nov. 28, 1912.

The machinery spaces occupy the 'amidship portion of the destroyer, the installation consisting of four Fore River-Yarrow watertube boilers. The vessel is fitted with two 18-stage Curtis reversible marine turbines, 63 inches in diameter, and capable of developing 5,500 shaft-horsepower each at about 585 revolutions per minute, which will give the vessel a speed of 29½ knots.

For the purpose of bettering the economy of consumption of steam at low speeds there has been fitted at the forward end of each turbine, and connected to it by means of a jaw clutch, a 10½-inch by 22-inch by 10-inch stroke-vertical, compound reciprocating engine, which at 16 knots is intended to develop 400 indicated horsepower at 280 revolutions per minute, with a steam pressure of 250 pounds in the high-pressure chest. The steam, after passing through this engine, is put through the turbine, and the energy remaining in the steam after passing through the reciprocating engine is extracted down to the last ounce of pressure in the turbine. Shop tests of this unit, conducted by a naval board last December, showed, according to the report of the board, that the gain in economy at 16 knots amounted to 33 percent, at 13 knots 62.4 percent, and at 10 knots 98.96 percent over the performance of the turbine under similar conditions of steam. The contractors guaranteed that the gain at 16 knots would be 25 percent. It is expected that the *Henley* will be the most economical torpedo boat destroyer in the United States navy at all speeds from 10 knots up to 31.

Communications of Interest from Practical Marine Engineers

Incidents Relating to the Design, Care and Handling of Marine Engines, Boilers and Auxiliaries; Breakdowns at Sea and Repairs

Efficiency of Turbines at Cruising Speeds

The 400-horsepower reciprocating engines which are to be installed forward of the 5,500 shaft-horsepower turbines (Curtis) of the United States destroyer *Henley* will probably give the desired economy at cruising speed, but in the case of similar installations in battlships the increased length of engine rooms would be a disadvantage and the engine would be large on account of the necessarily small piston speed.

To take a concrete case, consider the battleship *North Dakota*. She is a twin-screw vessel with Curtis turbines. At a speed of 21.6 knots the shaft-horsepower was 15,900 on each shaft, and the revolutions 280, while at a cruising speed of, say, 12 knots, the shaft-horsepower was 1,911 and the revolutions 143; that is, the revolutions were reduced to one-half and the horsepower to one-eighth. The steam consumption was 13 pounds per horsepower per hour in the first case, and 20 pounds per horsepower per hour in the second. Nineteen nozzles were used in the first case and four in the second.

If a clutch was put in the shafting abaft the turbine for direct drive at full power, it could be thrown out and a one to two reduction gear used for the lower speed, which, as it needs only 1,911 horsepower, would not require very heavy gearing. A greater ratio might be used so that the turbine could run above the normal speed and increase the efficiency. The clutch and gearing could be fitted in the shaft alleys, which are of little value except as space for engineers' stores.

Another installation which would make no change in the main shafting, except to add one gear to it, would be the addition of small high-speed turbine or reciprocating engine geared to the main shaft, the exhaust from same discharging into the main turbine. As the safety of the vessel would not be dependent on this auxiliary machinery, it could approach torpedo-boat design in speed and weight. Of course, in the case of the turbine the speed reduction could be very considerable and the turbine very small.

The Government is now making radical experiments in methods of power transmission on the colliers, but all for full power. Would it not be advisable to try the merits of the above propositions on similar war vessels? Any one of the installations would weigh less and take less room than the *Henley* type; in fact, none of them would increase the engine weights by more than 3 to 6 percent.

Brooklyn, N. Y. R. E. BARRY, A. I. N. A.

Explosion of an Intermediate Stop-Valve Chest

The steamship *T*——— was on a voyage from Bristol, in England, to Galveston, Texas. Everything during the voyage across had worked well, and when the explosion I am going to speak of happened the voyage was nearly at an end.

The stop valve I write of was an ordinary brass valve 10 inches in diameter. It worked by a rod and wheel from the starting platform. A brass nut was fitted in the saddle of the cover to take the spindle, which had a square thread ¼-inch pitch. The diameter of the cover was 18 inches, and the mean thickness was 1 inch.

No repairs had been required previous to this explosion. The machinery, etc., had all been inspected and passed by the superintending engineer.

We had come to anchor waiting for the weather to calm down so that we might get a pilot, and it was during this time that, without any warning, the cover of the intermediate stop valve blew off. Three of the studs were also broken off.

One of the engineers had opened the stop valves on the boilers, eased the throttle, and had also opened all the drain cocks; he then proceeded to open the intermediate stop valve and it was then that the explosion took place. The engineer, who was trying to open the valve, was severely scalded and laid up for some months afterwards. The noise of the escaping steam brought several others of the engineroom staff to the spot and, after groping about for some minutes in the steam, we managed to get the main stop valves shut.

We then set about repairing the chest. We had to drill out three 1-inch studs which were broken off flush with the face of the chest, and put three new ones in. We then got a piece of steel plate about 12 inches square and drilled holes to suit the pitch of studs and jointed all up. The steam was allowed to run straight through from the main stop valves of the boilers to the throttle, the valve and cover of the intermediate stop valve being useless; in this way we reached port and had a new valve and cover fitted. F. J. S. N.

A Kink in Gaskets

Being in a position where we didn't have any gasket to make a joint in the valve chest of a dense air ice machine, it looked as if there was going to be a loss of provisions, but one of the oilers suggested the following, which was carried out:

The sketch shows the valve chest, which was approximately 14 inches wide and 20 inches long, and the studs were moderately close together. We took some quarter-inch square packing and laced it round the studs, as sketched, and put on the cover and drew it down. This gasket lasted longer than any we had ever had, and since then I have given up cutting out flat gaskets and saved considerable time for ourselves and money for the owners. Usually common sense metallic packing is used in these ice machines; but they are quite a little trouble to handle, and I think that what is here suggested can be used not only in such a place but in many others advantageously. TRAMP STEAMER.

GASKET FOR A VALVE CHEST

Fitting a Tail Shaft Ring

Fitting a brass retaining ring on the tail shaft of the German steamer *Itauri*, without docking the vessel and while cargo was being handled, was the unusual feat recently performed in Seattle harbor by the Heffernan Engine Works. During her long passage from Europe, stopping en route at many ports along the west coast of South America, the *Itauri* was subjected to severe service, and when she reached this port it was found that the retaining ring was so badly worn as to require replacing. The engineering staff aboard stated

it was impossible to make the repairs without docking the vessel. As it was imperative that she discharge and be dispatched as quickly as possible, docking was the last resort. When the *Itauri* arrived she was drawing 13 feet aft. To put her down by the head as much as possible, 350 tons of iron were discharged from the afterhold, No. 1 hold was filled with 1,000 tons of flour, while No. 1 tank was filled and the after tanks were pumped out. This put the vessel down by the head by about ten feet, bringing the propeller high out of water. The shaft at the retaining ring was then partially under the surface.

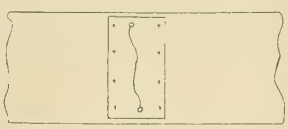
The brass ring was made in two pieces, dovetailing into each other, one section going under the shaft and the other on top. With the assistance of a diver the two parts of the ring were placed around the shaft, bolted together and screwed on, the work being completed within a few hours. Mr. Heffernan made good on his offer to repair under water, thereby saving much time and expense. Officers of the vessel would hardly believe that the work could be performed without docking, and were greatly pleased at what was accomplished, and local marine engineers are still talking about the feat.

Seattle, Wash. R. C. HILL.

A Condenser Breakdown

Most of the cases of marine breakdowns can be traced to some assignable cause, but others are to be classed purely and simply as mysteries. How they happen is beyond comprehension, and therefore the restoration of the plant to normal working order is only a partial solution of the difficulty, as one never knows when or under what circumstances the trouble may occur again. For this reason the marine engineer should not be satisfied merely with keeping his plant in running condition; he should be able to give a satisfactory reason for the troubles which assail the plant in order that they may, as far as possible, be prevented from happening again.

The following incident is, however, at present without explanation, and a solution of the difficulty will be welcomed by the writer: The figure shown herewith is a view looking



CRACK ON A CONDENSER

down upon the top of a condenser of the usual surface type found on board ship, showing a rather extensive crack which developed between two columns. How the fracture occurred no one knows, the only thing definitely known about it being that the condenser was found cracked, as shown, when the vessel was about seven days out of port. The way the trouble was discovered was by the condenser losing its vacuum, and as this happened very rapidly the inference is that the formation of the crack and the losing of the vacuum occurred practically at the same instant. The reason for the crack could, however, not be found. It might have been understood quite well if the engines had been warmed up quickly, leaving the condenser cold; but this was not the case, so the incident must rank as one of the mysteries which so often occur at sea.

The sketch also illustrates how the damage was repaired, although there is nothing extraordinary about that part of the subject. At each end of the crack a hole was drilled in the condenser and plugged in order to prevent the crack from extending. Then a piece of plate 5/8 inch thick was cut to amply cover the crack and secured to the condenser surface by means of 5/8-inch bolts, a sheet of jointing material being placed between the plate and the condenser surface to keep the vacuum.

The Pump Trouble

It was some time ago, I admit, that the late chief engineer of the good ship *Sun* found himself a stoker on the tramp steamer *Anna,* not *Ann.* It wouldn't have been wise to put any question as to the age of this vessel within the hearing of the captain. Yes, I was stoking with a first-class certificate in my clothes, but I regret to say that my earthly possessions consisted of what I had on, and that certificate; and my main wish was for cooling drinks and to get away from shore. Yes, it was "booze" that did it, but that was long ago and another story.

I was picked up by the chief engineer of the *Anna* for no other reason that I know of except that I was white and spoke English. He was a down-East Yankee, weighing about 110 pounds, and I am sorry to say that his clothes and traps bore the name of "Lomedieu," yet the certificate of the chief engineer of the *Anna* was not spelled that way, but "McPherson." At that time in my life I did not care much about such matters.

After twenty-one days I got "noticed," and think the chief had been prowling around my clothes when I was asleep and saw the certificate. At any rate, I was taken into the engine room. Two days later, I was told to overlook a boiler feed-pump which had suddenly given out, or rather, instead of working its usual twenty or so strokes a minute, it took to making two or three hundred or more, and while it pumped some water it didn't pump much. I took off the water end of the cylinder head and steam end, as I supposed that the water piston rings were broken or the soft packing given out, and took out the piston rod. Right here let me say that the *Anna* had its work done cheap when repairs were concerned, and the piston rod was a sample of the style of work demanded, and obtained and accepted, being a piece of cold-rolled shafting with the water piston riveted on one end and a die-cut thread and shoulder on the steam end. I found both ends O.K. and nothing seemed to be the matter. I reported to the chief, who took a look, and told me to close her up again and use the old gasket. We did not use the pump for several days, and only started it up, when we got into port, to wash boilers; then it seemed to work all right for a day of two.

By that time I was feeling all right, and the chief told me that I should get no more money, but I was to be his "First," and I was to attend to my duties and keep my mouth shut and my eyes open. We started out a day or two afterwards, and after a few hours I started up the pump. It worked all right for a few minutes and then it began to fly away, and we had our troubles with it; but it kept on feeding sufficient for the purpose.

The chief made some uncomplimentary remarks about me, and then had the pump taken apart himself, but could find nothing; but, being called away before it was put together, I had a chance to look it over, and here was the trouble.

On account of the cheap job no shoulder had been turned on the water end of the piston-rod, but it had just been shoved in "any old way" and riveted over. After a while this worked loose and the piston-rod would keep on working through the piston, sometimes carrying it along with it and sometimes not. I took a great deal of pleasure in calling the attention of the chief to the fact that it paid to do a job well. He remarked this was true when you didn't have to pay for it yourself,, but he had noticed that engineers who had no interest in the ship had a change of heart when they got an interest in it as regards repairs. ANTI-BOOZE.

Work on the Argentine battleship *Rivadavia* at the yards of the Fore River Shipbuilding Company, Quincy, Mass., has progressed to the stage where the turbine rotors are being placed on board. Much of the auxiliary machinery is already in position, the boilers are complete and the condensers are ready to be installed as soon as the turbines are in position.

Review of Important Marine Articles in the Engineering Press

A Comparison of the Cost of Dreadnoughts in England, Germany, France, Austria and the United States.—Translated from an article of Naval Constructor Louis Barberis, R. I. N., in Rivista Marittima, by A. Conti. Attention of the reader is called to different methods of accounting used in the countries compared. After correcting for these differences, according to the best knowledge obtainable, costs per ton and for the completed ships are given. The most valuable part of the paper consists of tables of costs of dreadnoughts of all the Powers sub-divided into the general items of expense going to make up the completed ship. 6,200 words.—*Journal of the American Society of Naval Engineers,* February.

A Further Note on Approximate Stability.—By Arthur R. Liddell, Charlottenburg. General rules have not yet been laid down for the determination of a suitable metacentric height for vessels of different sizes and types nor have the principles that underlie its variations been made clear. In this article a suggestion is made with this as its purpose. To make the consideration general, the stability conditions of rectangular blocks of different proportions of depth to breadth are dealt with. If curves of levers be laid off for such a block, or series of blocks, with molded depth to breadth ratio ranging from .4 to .6, it will be seen that with a given height of metacenter the range of stability varies considerably. If, however, a particular range of stability be laid down the metacentric height corresponding will vary so that it is too large in some of the blocks and too small in others. To lay down distinct limits for either is impossible, and a compromise must be made in some way. The suggestion of the author is to establish a certain fraction of the breadth as a desirable metacenter for a block with molded depth equal to one half breadth, and for all other proportions of block to halve the difference between this height and the metacentric height that would give the same range as the standard proportion. The ranges of positive stability thus arising will have values that are approximately means between the two cases given above. The remainder of the article consists of examples of the use of this suggestion, and in showing how impossible it is to find a method for accurate use that covers all cases. 2,700 words.—*The Engineer,* February 23.

The Davis Gun-Torpedo.—The essential features of this invention is the substitution of a gun firing a shell for the explosive head of a torpedo. By the use of vanadium steel of very high elastic limit an 8-inch gun and shell is mounted in the warhead of a torpedo with an actual saving in weight over the usual charge of gun cotton carried in the largest size of explosive head. The object is to project the shell of this submarine gun through all torpedo nets and armor within the vitals of the ship itself where the charge of the shell is exploded by means of a time fuse. Tests have been carried out in the waters of Chesapeake Bay by the inventor, Commander Cleland Davis, U. S. N., and more recently by the United States Government. These have shown that great destruction results from the use of the weapon, and all claims for it have been substantiated. Some difficulty has been experienced in making the fuse act at precisely the right time, but otherwise the penetrative possibilities of the attack have been fully realized. Illustrated with photographs and diagrams. 1,900 words. —*The Engineer,* February 23.

Floating Dock for Testing Submarines.—A floating dock of novel construction has recently been built by the Fiat San Giorgio, Spezia, the chief object of which is to enable external pressure tests to be applied to hulls of submarines without having recourse to deep-sea diving tests. The main portion of the dock consists of a hollow tube, having one end permanently closed, the other fitted with a hollow circular door. Two centrifugal pumps enable the dock to be lowered to receive a submarine and rise with its load, while a third pump enables the pressure to be maintained within the dock for testing purposes. When floating light the displacement is said to be 500 tons, when loaded 925 tons, and when docking a vessel the draft is increased from 7 feet light and 10 feet loaded to 17 feet 9 inches. 550 words. Photographs and drawings.—*Engineering,* February 23.

Anti-Rolling Devices for Ships.—By E. C. Given, M. Inst. C. E., M. I. Mech. E., M. I. N. A. Read before the Liverpool Engineering Society. A well-written summary of the use of anti-rolling devices from their introduction to the present time, giving for each instance the name of steamer, her size, the general characteristics of the system used and its results. More is said concerning the recent developments by Dr. Frahm, of Blohm and Voss. A recent paper by the inventor has been reviewed in these columns. This system has been successfully tried on the Cunard Line steamship *Laconia,* and will be installed in the *Aquatania,* now building. A brief statement of the principle on which the device works may be said to be the use of a secondary and artificial resonance to damp the primary resonance between the waves and ship. A ship rolls in periods of her individual oscillation even if the impulse be more or less irregular. As the ship lags 90 degrees; that is to say, a quarter of her period behind the wave, so the phase of the tank water lags 90 degrees behind the ship; that is, 180 degrees behind the wave, and the result is that the water having been put in motion by one wave of a series damps the rolling tendency from the next. 4,000 words. —*The Steamship,* March.

Screw Propeller Design.—By Capt. C. W. Dyson. After the publication of the article with the above title in the August, 1911, number of the *Journal of the American Society of Naval Engineers,* the *London Engineer* called attention to the fact that it is not the block coefficient of the ship alone which should be used in determining its propeller. This point has been thoroughly understood by the author, but not until this contribution has he found suitable form for expressing this variable. By adopting the system of "Parent Lines" used by Naval Constructor Taylor in his book on "Speed and Power of Ships," a "Guide Chart for Correction of Block" has been produced, and is herewith submitted as the most practicable method of graphically illustrating the correction of block to be used in the selection of slip charts where any ordinary departure from the relative dimensions of the standard basic vessel occurs. Capt. Dyson then proceeds to explain the development of the corrective chart and gives it for use in design. 1,200 words.—*Journal of the American Society of Naval Engineers,* February.

The Possibilities of Flue Gas Economizers on Board Ship. —By Mr. R. Royds, M. Sc., and Mr. J. W. Campbell, M. Sc. Suggested by previous experiments for this form of heat saving on board ship and prompted by the recent adoption of feed-water heating on locomotives of the Egyptian State Railway, the authors have given extensive reports of experiments carried on at the Glasgow and West of Scotland Technical College. The purpose of these was to determine the effect of varying speeds of water and air through tubes on the transmission of heat from these mediums to the surrounding air. The report is mathematical in its nature, but gives also tabu-

lated data and a statement of practical results obtained. Useful results are claimed to have been obtained, although it is more of a store of experimental data than a statement of practical knowledge. Following the paper is a discussion by various members, both for and against the practical adoption of the apparatus suggested. 7,000 words.—*Transactions of the Institute of Engineers and Shipbuilders in Scotland;* Fifty-fifth Session, 1911-1912.

The Naval Reciprocating Steam Engine, its Characteristics, Dimensions and Economics.—By Ernest N. Janson. A careful review of reciprocating engine practice in the United States navy for the past twenty years in all principal considerations of design. The article refers especially to battleship engines, though allusions are made to engines of other types of craft. It gives tables of design, data and a chart showing the progress in engine performance during that time. It contains a drawing of the elevation of one of the engines of the battleship *Delaware.* On the whole, one of the clearest reviews of the subject we have seen for some time. 13,500 words.—*Journal of the American Society of Naval Engineers,* February.

Alternating Current on Shipboard.—By Lieut. A. Norris, U. S. N. A careful and complete statement of the case of the alternating current versus direct current on board warships in every practical detail. All electrical installations at present in use on shipboard are on the direct-current system. That the use of alternating current is practicable may be inferred from its use in the German navy and several foreign merchant fleets. The use of this system on shore is well known to have advantages not obtained by the use of direct-current systems. Some of these are: cheaper cost of installation, cheaper cost of production per kilowatt-hour, cheaper cost of mechanical and labor upkeep, less space and weight required for the plant, simpler construction and higher efficiency of machines, increased ease of voltage regulation. The scope of the paper is to outline a tentative design for use on a battleship under service conditions, and as the first step in accomplishing this the author lists all motors required for such a service. Next, he considers types and sizes of motors best filling these needs. The induction motor is the type depended on to give best results in this service and characteristic curves are given for suitable machines. All departments of the ship's electric installation are dealt with from the generating station to the wiring specifications, and in summing up the case a list of advantages to be derived from the change seems apparently unanswerable. Perhaps the reason for the continued use of the direct-current service is that stated in the introduction to this paper, that although electricity has been used for lighting and power on board ship for a number of years the question of economy in its use and application has had comparatively little consideration. 15,000 words.—*Journal of the American Society of Naval Engineers,* February.

Boilers Fired with Liquid Fuel.—An abbreviated translation of a paper by Major Giulio Fumanti, of the Italian Corps of Naval Architects before the first Congress of Marine Engineers held in Rome Nov. 12, 1911. The paper is evidently a complete treatise on the subject, and while little new matter is presented, the arrangement is especially good and complete from the standpoint of the naval engineer. Although the difficulties in using oil fuel, as stated, are high cost and difficulty of obtaining a regular supply, the advantages more than outweigh these, especially for naval vessels. Much care must be exercised in guarding against fire and shells, but these can be guarded against to some extent by using double-bottom tanks for storage and pumping to boiler rooms as required. The author favors the steam atomizing system for regularity of service. Figures are given showing time required for raising steam for starting or for full speed from time of giving orders and other like situations. In merchant service fuel consumption is stated to be 1.1 to 1.0 pounds per indicated horsepower per hour. 2,500 words.—*Engineering,* February 2.

Note on the Performance of Marine Turbines at Reduced Speed.—By E. Buckingham.—This article is as much a study of design of marine turbines for naval service as it is a note on their performance. For it is the purpose of the study of operating conditions at reduced speeds to design with better regard for that very essential feature of modern naval service. It is well known that while at full power turbines may show an acceptable performance from the standpoint of economy, it has so far been a very different thing at reduced speeds. So well is this known and generally accepted that separate cruising turbines have been installed where the necessity of the case demanded and space permitted. The purpose of this article is the determination of pressure distribution at reduced power and the relation of the pressures to the steam flow with their applications to design of turbines for economical service. These have been accocmplished as far as data at hand have furnished grounds and precision of measurements have permitted the deduction of a rule. From trials on turbines of the Salem and North Dakota, and comparison with reliable authorities on turbine design, the pressure distribution at reduced power has been determined and its relation to steam flow discovered to be approximately as follows: "When the steam flow is cut down by nozzle regulation, the absolute pressure at every point in the turbine except close to the condenser is reduced in the same proportion as the steam flow, if the feed to the steam chest is kept uniform in quality and pressure." Applications of this rule to practical design in several bearings are then taken up and explained. 5,600 words.—*Journal of the American Society of Naval Engineers,* February.

The Telefunken System of Wireless Telegraphy.—A detailed description of the apparatus of this most widely adopted system of wireless telegraphy. It was originally evolved in Germany, where, after the amalgation of two companies which had carried on business in wireless telegraphy separately, it received the name Telefunken. The system represents a combination of the Braun-Siemens and the Slaby-Arco systems, and has been built up on the researches and inventions of two well-known German scientists, Prof. Slaby, of Berlin, and Prof. Braun, of Strassburg, the latter of whom received the Nobel prize for physics in 1910. Of the 1,500 stations in operation at the beginning of 1909, 673 were Telefunken stations. The largest standard type of station on the new Telefunken system is said to require a primary alternating current energy of about 40 kilowatts. Radiograms sent in a southerly direction from Germany have been picked up by steamers as far as 2,500 miles distant, and in a westerly direction as far as 3,200 miles. In this system the instruments may be tuned very accurately and the variously tuned transmitters easily distinguished from one another by their notes, which are musical in their purity. The range of tones possible varies from 200 to 2,000 vibrations per second. The article contains a detailed description of transmitters and receivers, signal call apparatus and sound intensifier, with photographs of different sizes of sets made both for land and marine work. 6,700 words.—*The Steamship,* March.

Engineering Works at the Rosyth Naval Dockyard.—This, the second instalment of the series, continues the description of the concrete construction of the river walls and piers of this new naval station. The details of the work are given with some degree of completeness, the assumed conditions and designing factors furnishing satisfactory data for similar work. 2,100 words.—*Engineering,* February 2.

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Changes to be made in copy, or in orders for advertising, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 10th of the month.

Confronted by the most appalling disaster in the history of navigation, shipbuilders and navigators can no longer fail to recognize that their oft-asserted mastery of the sea is far from perfect. Great faith has been placed in the achievements of the modern shipbuilder, and the prudent navigator has feared nothing at sea but the land and unseen dangers. Even the timid ocean traveler has almost lost sight of the element of risk involved in the hidden menaces so long eluded by the skill of seafaring men, until at a blow one of the mightiest creations of naval architecture has been stricken and its ghastly toll exacted.

The *Titanic* was side-swiped, and the blow was dealt by an iceberg unseen until scarcely more than a ship's length ahead. The inability to detect an unlooked-for hidden obstacle in the path of the vessel at night, coupled with high speed and large size of the vessel, which mean a tremendous force for the thin shell plating of the ship to resist in a collision, all tend to make such a result inevitable. Overwhelming as the disaster is, from it must come an immediate and widespread development towards greater safety in ship construction, safer methods of navigation and safer appliances for preserving life when a ship is thrown upon her own resources under the most disadvantageous conditions.

In the first place, outside of collisions, there is little for the modern steamship to fear. Other risks have been practically eliminated. Even collisions, when between two vessels, have never proved so disastrous, because they usually occur in fogs when the ships are running at reduced speed, and the less damaged ship is usually able to assist the other. Much has been done by the United States Revenue Cutter Service in the location and removal of derelicts, and undoubtedly this work will be steadily pushed forward. There remains, however, the menace of the iceberg, which is still only a half conquered foe, and which has just proved its terrible destructive force. Icebergs, however, are not so numerous that they could not be located and traced with considerable certainty, so that ice regions could be avoided in regular ocean travel if the proper precautions were taken.

Even the greatest precautions in eliminating as much as possible the causes for collisions should not in any way deter every effort toward utilizing every means of protection for passenger ships from damage by collision. The part of the ship which has always been considered as the most likely to be injured by collision is some part of the bow, and the provision of a collision bulkhead and the use of transverse watertight bulkheads separating the holds in the forward part of the ship has been expected to give sufficient protection against a head-on collision. In most cases, if the bulkheads are absolutely watertight and of sufficient strength, this has proved a sufficient precaution; but as the speed and size, and, consequently, momentum of the ship when under way, increase, there is very good reason for subdividing the forward part of the vessel still further by the introduction of either a center line bulkhead in the forward holds, or by the use of an inner skin extending up to the waterline. The weights involved by such design, and the question of stability in the event of damage to one side of the ship only, must, of course, be carefully treated, as in warship design.

Side-swiping a vessel is an accident which has almost never happened, but when side-swiping extends for a considerable length of the ship, a system of protection by transverse watertight bulkheads is of little use. Some protection against such an accident can be obtained, as was done in the *Lusitania* and *Mauretania,* by the use of wing bunkers, with the longitudinal bunker bulkheads made watertight or virtually in the form of an inner skin to the vessel. This type of construction can be used in almost any ship, and if longitudinal framing is used with a corresponding saving in weight of the outer structure the additional weight of inner longitudinal bulkheads through the boiler space would not be so serious. Some additional saving in weight could also be obtained by the use of watertube boilers in place of the Scotch boiler, which has been steadfastly adhered to in merchant vessels.

Improved Engineering Specialties for the Marine Field

Life-Saving Appliances

The loss of life in the *Titantic* disaster emphasizes more strongly than ever before the absolute necessity of equipping all ships with the best and most efficient life-saving equipment that can be obtained. Only recently some new products along this line have been placed on the market by the Welin Davit and Lane & De Groot Company, Con., Long Island City, which are worthy of careful consideration.

Fig. 1 shows a ring-buoy that has the same appearance as the common type but differs greatly in construction. The ordinary ring-buoy now in use, made of cork, absorbs a great deal

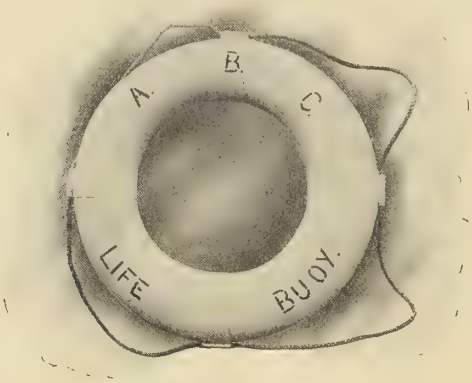


FIG. 1

of moisture, and therefore rots from the inside. The necessity of painting these every year in order to keep up their appearance and preserve them adds considerably to the weight, so that after a few years they cannot always be relied upon. The A. B. C. ring-buoy is made up in the same sizes as the regular cork one but is about 20 percent lighter in weight, though double the strength on account of it being made up of solid Balsa wood, turned to perfect shape and treated with an impervious solution which prevents the penetration of all moisture and water. The canvas cover is also of better quality

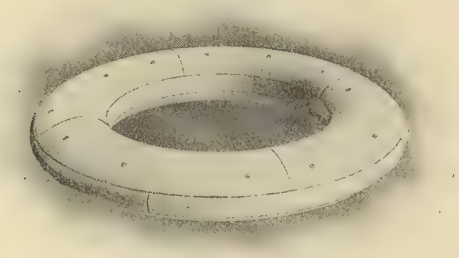


FIG. 2.—CONSTRUCTION OF A. B. C. LIFE BUOY

than that used on the cork ring-buoy, and if painted like the cork one it may in time gain weight, due to the paint but not due to the absorption of water. Should this accumulation of paint amount to 3 pounds, which would be an unusual condition, the A. B. C. ring-buoy would then weigh no more than the cork one, as it is 3 pounds lighter than that called for in the navy specifications. The superior durability of this buoy is therefore manifest.

The A. B. C. life raft, Fig. 2, is another illustration of what can be accomplished with this light and strong wood. This raft consists of about 50 board feet of wood and will support eight persons in the water. Yet, notwithstanding this, one man can easily handle this raft, and if need be throw it overboard from the deck of a yacht or motor boat, a type of boat for which it is particularly adopted. Experience has shown that there is very little room to spare for the regular metallic life raft on such small craft, and, further, there is no way of launching such a raft when needed. As all life-saving appliances on motor boats are needed quickly in case of accident, the value of the A. B. C. life raft is apparent. It is made in three sizes, varying in length from 4 to 7 feet.

FIG. 3

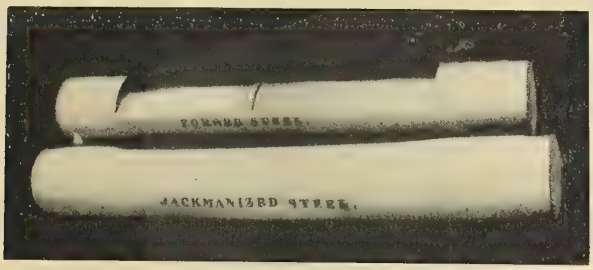
Besides the ring-buoy and life raft just described the products of this company include the A. B. C. life preserver, which has been on the market for a number of years. These are made of Balsa wood, and are one-third smaller and lighter than the ordinary cork belt, which makes them of particular value to ships carrying a great number of persons. It is well known that life preservers made of cork, tule or other material absorb moisture and retain it, and there is therefore the constant necessity of repairing and renewing the covers, due to mildewing and rotting, principally from the inside. The life preserver manufactured by this company, however, it is claimed, does not absorb moisture on account of its waterproof coating, and there is therefore no opportunity for destruction from the inside. By actual test the company states that it has been proved that this life preserver will outlast three or four times the ordinary cork belt and will retain its buoyancy indefinitely.

One of the most important life-saving appliances manufactured by this concern is the Welin quadrant davit, well known for its ease of manipulation, reliability, adaptability for launching boats under all conditions and for the saving of deck space, both longitudinal and transverse, which they permit. The company also manufactures a complete line of standard lifeboats of both metal and wood, which involve special improvements accepted and commended by the United States Government inspectors. Another product of the firm is also a type of non-sinkable and non-corrosive yacht and motor boats, built of steel, bronze and Monel metal.

After June 1 the firm will be known as the Welin Marine Equipment Company, and its president states that the company will be pleased to give estimates without charge on up-to-date boat and launch equipments, and also to assist in drawing the designs if furnished with the necessary deck plans of the ship under construction.

"Jackmanized" Steel

Joseph Jackman & Company, Ltd., of Persberg Steel Works, Sheffield, manufactures a special steel for dredging work called "Jackmanized" steel. After severe tests this has proved to be eminently suited for dredger pins, bushes, tumbler shafts, etc. This steel, it is claimed, can be forged to any desired dimensions and still retain its hardening face. "Jackmanized" steel is a substitute for case-hardened iron and steel, and only requires to be heated and immersed in water or oil to be intensely hard on the surface to a depth of ⅛ to 3/16 inch, the center of the bars, or turned pins, remaining soft and tough, thereby retaining almost their original strength before



hardening. The illustration clearly shows the comparative quality of "Jackmanized" steel. It depicts two lower tumbler shafts taken from a double ladder dredger. Both shafts were put to work in December, 1902, and taken out November, 1903; each when put in measured 9 inches diameter by 5 feet 3 inches long and weighed 10 cwt. The actual time at work dredging is officially given as:

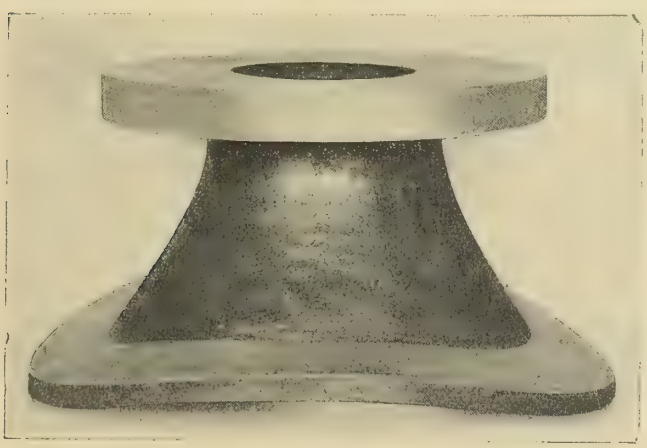
Mild steel, 2,255 hours (worn down 2 inches).

"Jackmanized" steel, 2,521 hours (worn down 13/16 inch).

Another feature which will be readily noticed is the appearance of the two shafts, the former being very much reeded, whereas the latter is perfectly smooth and sound, although it had worked 266 hours more than the ordinary steel shaft.

Taylor Seamless Forged Steel Boiler Nozzle

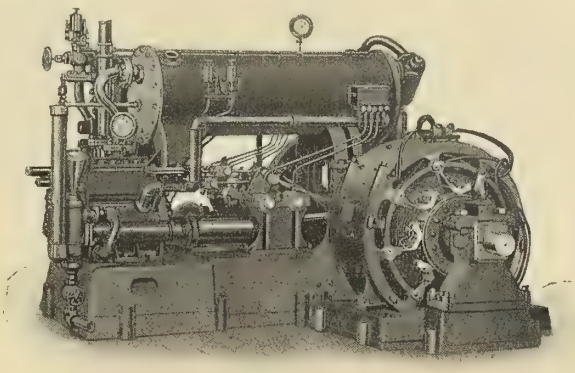
The American Spiral Pipe Works, of Chicago, Ill., manufactures a boiler nozzle which is forged from a single piece of open-hearth steel without a weld. The proportions of this nozzle can be seen from the illustration. A special process is used for forging the nozzle from a single piece of steel by



which the neck just under the flange is made heavier than the remainder of the body, thus providing against the working strains which are greatest at this point. The distance between the flanges is sufficient to allow the insertion of bolts from the under side, thus obviating the use of studs. The saddle flange is of sufficient diameter to enable the use of power riveters for attaching the nozzle. The nozzle may be heated and the saddle flange bent to the required circle with no separate part to become loosened when heated. It is claimed that this type of nozzle forms the safest and most reliable connection between the boiler and high-pressure piping.

The Allen Dense Air Ice Machine

The Allen dense air ice machine, manufactured by H. B. Roelker, 41 Maiden Lane, New York, is so constructed that it can be placed conveniently in the main engine room of a steamship, where it can be attended to by the regular engineers along with their usual work while the meat-room or refrigerated compartment is in a distant part of the vessel. The machine utilizes only common air at reasonable pressures and only machinery similar to usual steam engine machinery, there being no auxiliary pumps or other machinery outside of the ice machine. Instead of taking air from the atmosphere or from a cold room and after refrigeration discharging it again into the room, the Allen machine keeps a charge of air at 60 pounds gage pressure in the machine and the conveying and refrigerating pipes, and uses this supply of air over and over again, compressing it in the air compressor, then cooling



it in a copper coil surrounded by circulating water, expanding it in the expanding engine to reduce the temperature and pushing it when cold through the conveying pipes to the cold room, where it also remains inside the pipes and does its refrigerating by radiation through the surfaces of the pipes, then it passes back through the same cycle and repeats the performance.

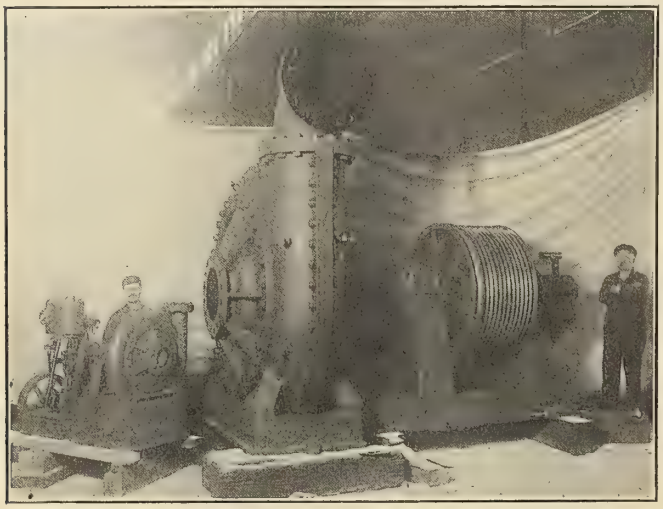
Power for the whole apparatus may be supplied by either a steam cylinder or by an electric motor. The machine illustrated is a 3-ton machine, electrically driven. The various parts of the machine, besides the power plant, consist of the air compressor cylinder, which compresses the air to about three times the entering pressure, and thus heats the air. The compressed hot air then passes through a copper coil in a bath of water, which cools the air to the temperature of the cooling water. Next the air passes through a return air cooler, which further cools the compressed air by means of the cold air returning from the meat-house or refrigerated compartment. After this the cooled compressed air is admitted to the expander cylinder till it fills one-third of the volume of the cylinder. It is then shut off, and the piston, continuing its passage to the end of the cylinder, expands the air to about the pressure at which it entered the compressor. This expansion cools the air about as much as the compression heated it, therefore leaving the air at a temperature of practically 60 degrees F. below zero. This air is then discharged into a well-insulated pipe, which conveys it to the compartment which is to be refrigerated.

The only additional part in the condensed air ice machine is the so-called primer pump, a simple small plunger pump, which compresses the atmospheric air into the machine at

starting and makes up the losses caused during the running by leakage from stuffing-boxes and pipe joints. There are two traps, which remove refrigerating oil and water from the air and keep it pure while passing through the pipes.

18-Inch Hydraulic Dredging Pump

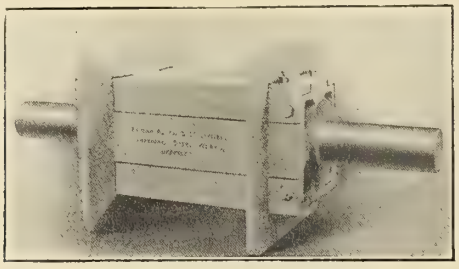
The Kingsford Foundry & Machine Works, Oswego, N. Y., has recently constructed for the Chicago, Burlington & Quincy Railroad an 18-inch hydraulic dredging pump, a view of which is shown herewith. The pump has a manganese steel liner 1



inch thick and a shell 2½ inches thick. The total weight is 33,000 pounds and the total height 10 feet 5 inches. The small pump shown in the photograph is a 5-inch side suction pump connected by a silent chain to a 6-inch by 6-inch vertical engine. The outfit is used for priming the large pump.

Steel in Dredger Building

In our last dredger number we called attention to the increasing use of special steels in dredger construction, notably the use of manganese steel. Herewith we show a cast steel dredger tumbler and shaft with renewable corner pieces

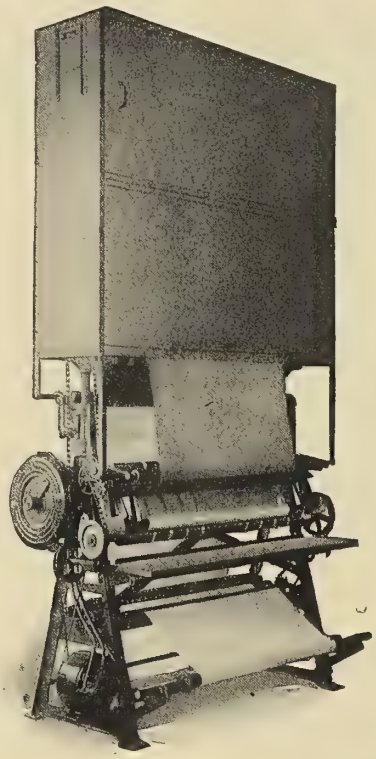


of Allen's manganese steel, manufactured by Edgar Allen & Company, Ltd., Imperial Steel Works, Sheffield. This company also makes dredger pins of various sizes and designs of the same material, and dredger buckets and links with Allen manganese steel bushes.

A Valuable Accessory to the Blue Print Room

Sensitized blue print paper is very easily affected by atmospheric conditions, so that the sooner it is used after coating the better are the results. The C. F. Pease Company, Chicago, Ill., has placed on the market a machine which coats the paper at the rate of twenty-five or thirty 50-yard rolls per day, enabling the operator to start the coating machine and do his blue printing at the same time.

This machine, called the "Simplex," occupies a space of only 3 feet by 5½ feet, and can be set up against the wall. The apparatus is entirely self-contained, and is operated by a ¼-horsepower variable speed motor, controlled by an electric speed changing device, so that any speed can be instantly secured, according to the quality and thickness of the paper that is being coated. A roll of uncoated paper weighing 150 pounds is placed on the receiving spindle. The paper is then carried under the rubber-covered coating roller up through the drying oven, which may be heated either by gas, electricity or steam, after which the sensitized paper is automatically wound



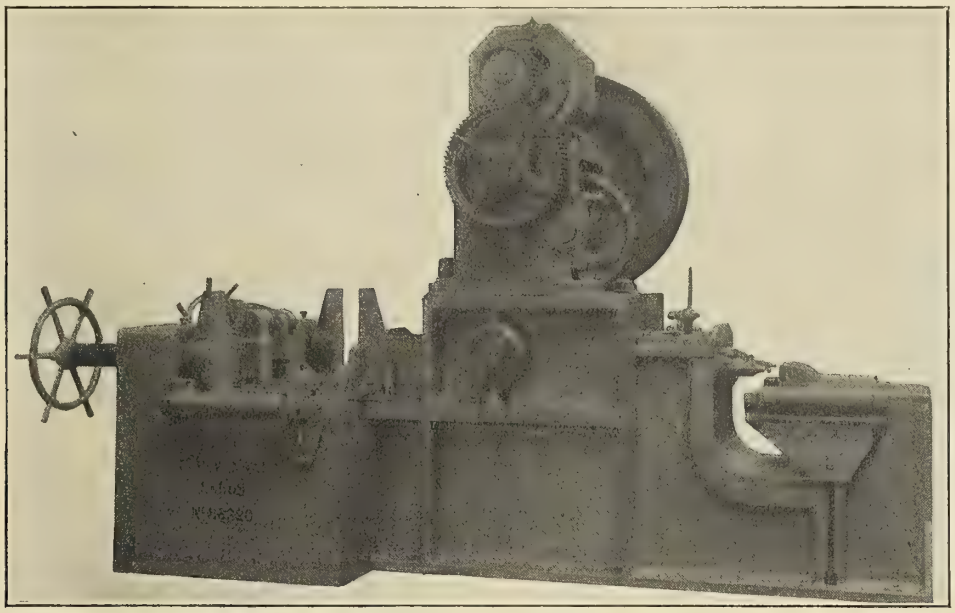
up in a tight roll and in any length desired. An automatic measuring device is used, which is so arranged that just before the desired length of paper is reached a bell is struck, notifying the operator in time for him to cut off the paper and start a new roll.

With this apparatus it is claimed that it is possible for the operator, within twenty minutes after the machine is started, to have a fresh roll of paper ready for printing, and every fifteen or twenty minutes thereafter as long as the machine is in operation. The maximum capacity is twenty-five to thirty 50-yard rolls of paper per day. The manufacturers claim that the cost of drying by gas does not exceed 5 cents per hour, while the cost of operating the ¼-horsepower motor is nominal. The standard machine is of a width to coat paper 42 inches or narrower, but it is applicable for any desired width; in fact, machines of this type have been built for coating paper 66 inches wide, or for coating a 30-inch and 36-inch roll side by side.

Scriven's Combined Horizontal Punch, Beam Bender and Bulb Shearing Machine

Our January number contained a very complete description of the combined punch, bending and shearing machine manufactured by Scriven & Company, of Leeds, for beam-shed work in a shipyard. Herewith we reproduce a photograph of the machine showing the details. The machine consists of a twin horizontal punch at one end and a combined beam bending and bulb shearing device at the opposite end The twin

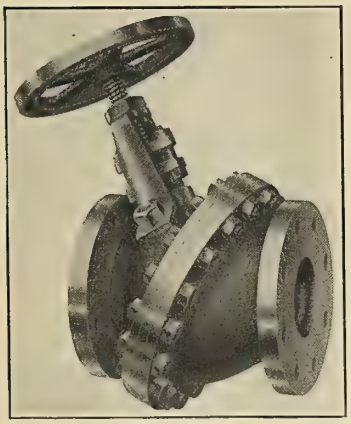
punch permits punching two different sized holes in the same bar without changing the punch or without any extra handling of the bar. The bulb shearing apparatus is designed to take off the bulb from a beam for a length of 6 inches or shear out

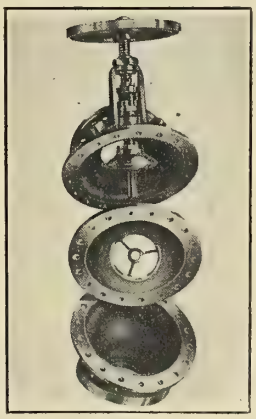


a piece of the leg 6 inches at one cut. The beam-bending device has a capacity of handling beams 15 inches deep. The whole machine is of massive design, capable of doing the maximum work continuously at a speed of thirty strokes per minute at both ends.

Patterson-Allen Forged Steel Valve

A special line of valves for superheat and other high-pressure installations is manufactured by the Patterson-Allen Engineering Company, New York. The construction of the valves is shown in the illustrations. They are made entirely

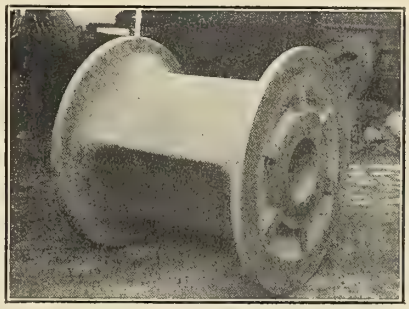




from forged steel boiler plate with Monel seats, Monel disks and nickel steel steams. They are said to be one-third lighter than cast steel valves of equal capacity. The valves are all forged in steel dies, which it is claimed absolutely guarantees uniform thickness throughout, and they are required to stand a hydrostatic test pressure of 1,500 pounds to the square inch.

Special Steel for Dredge Machinery

Experience has shown convincingly that for such parts of dredging machinery as are subject to severe wear and tear no other material gives such good results as the recently-introduced alloy steels, the characteristics of which are great toughness and durability. Such parts as pins, bushes and bucket lips are made by Thomas Firth & Sons, Ltd., Norfolk Works, Sheffield, of "Firth's Norfolk" manganese steel, which offers great resistance to wear, while being also characterized by uniform hardness and toughness throughout, a combination most essential in dredger work, since there is no fear of unexpected or premature breakage of parts made from this



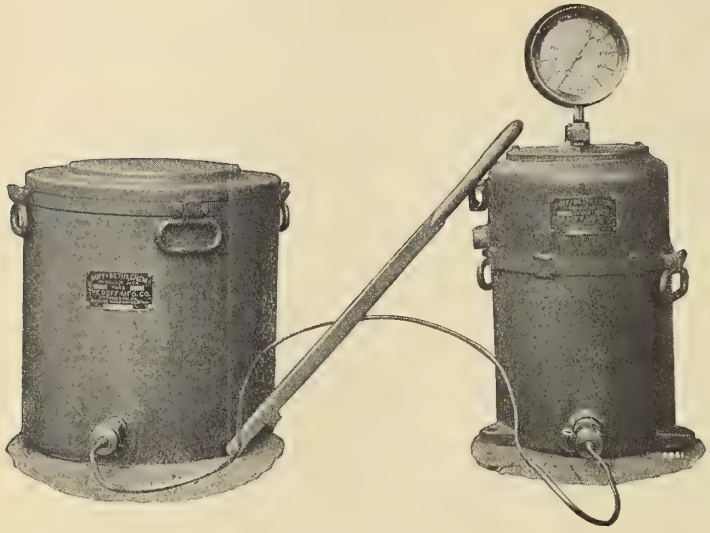
material. For tumblers and buckets this firm also makes a special quality cast steel, while the links can be supplied either cast or forged.

A Powerful Jack

The United States Government has recently purchased from the Duff Manufacturing Company, of Pittsburg, Pa., a Duff-Bethlehem hydraulic jack capable of lifting a load of 500 tons. This jack, which is intended for use in the Washington navy yard, is of the independent pump type, consisting of two distinctly separate parts, one containing the water reservoir with its pump chambers and the other the ram or lifting mechanism. Flexible copper tubing, capable of withstanding a pressure of 10,000 pounds per square inch, connects the two parts. This arrangement permits of the ram being placed in any position where there is sufficient room for it to rest, while the pumping mechanism can be placed at a sufficient distance to allow the operator plenty of working room.

The pump is of the improved Duplex type, providing an accumulative stroke on the upward motion of the pump piston and a working stroke on the downward movement. The pump is so arranged that it is claimed a light load can be lifted five

times as fast as a heavy load. This differential speed is automatically spring controlled, and requires no regulation of valves by the operator. The high speed is used for loads up to 35 percent of the capacity of the jack. In lifting loads greater than 35 percent of the total capacity the spring-controlled valve automatically opens at the predetermined pressure per square inch, and the pump becomes single acting, working on the down stroke only.



Another feature of this jack is the gage, which shows the exact lifting pressure that is being exerted. This gage acts as a scale, and registers in tons the weight that is being lifted.

North British Dredger Hose

A dredger hose of exceptional size, manufactured by the North British Rubber Company, Ltd., at Castle Mills, Edinburgh, is shown in the accompanying illustration. This is used for suction work in disposing of the spoil from dredging.

MR. T. M. CORNBROOKS has been appointed chief engineer of the Maryland Steel Company, Sparrows Point, Md.

DR. RUDOLPH DIESEL, D. E., D. Sc., director Verein Deutscher Ingenieure and inventor of the Diesel engine, was made honorary member of the American Society of Mechanical Engineers April 30.

CHIEF ENGINEER A. G. ERICKSON, of the Metropolitan Line steamship *H. M. Whitney*, recently met with a rather painful accident which caused him to lay off for one trip, but we are pleased to find that he has completely recovered.

MR. JOHN DICKEY CULEERTSON, second vice-president and treasurer of the National Tube Company, died suddenly at Pittsburg, Pa., on March 13.

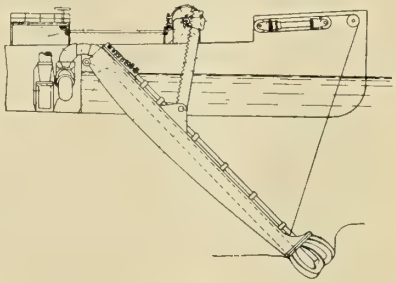
Selected Marine Patents

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

1,013,669. SUCTION DREDGER. FRED LOBNITZ, OF CROOKSTON, SCOTLAND.

Claim 1.—In a suction dredger the combination, with a ladder having a suction pipe or passage, of a rotating cutter carried by said ladder,



means for operating the cutter, means for holding the cutter down to its work, and means for allowing said holding means to slip when a certain pressure is exerted thereon. Nine claims.

1,013,928. APPARATUS FOR LOADING VESSELS. JOHN T. CLARK, OF NEW YORK, N. Y.

Claim 2.—In an apparatus, a cage, a plurality of movable members carried thereby, means co-operating with the respective movable members for tilting said movable members in oppositely inclined directions, and means for controlling the vertical movement of the cage. Seventeen claims.

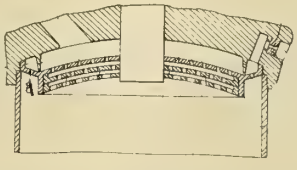
1,014,014. AUTOMOBILE TORPEDO AND METHOD OF AND APPARATUS FOR ITS PROPULSION. HUDSON MAXIM, OF HOPATCONG, N. J.

Claim 4.—The method of generating a motive fluid for torpedoes and the like, which consists in subjecting a self-combustive fuel to an initial pressure at the time of ignition, burning said fuel under pressure, and controlling the rate of combustion by controlling the pressure under which the burning takes place. Twenty claims.

British patents compiled by G. E. Redfern & Company, chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 21 Southampton Building, W. C., London.

781. HEATING DEVICES FOR USE IN TORPEDOES AND THE LIKE. SIR W. G. ARMSTRONG, WHITWORTH & COMPANY AND W. H. SODEAU.

The air or other gaseous supporter of combustion, on entering a combustion chamber, passes through one or more perforated deflector plates,



one of which is adapted to form, with the head of the combustion chamber or a part carried by it, a conduit from which water or other vaporized liquid is discharged on to the walls of the chamber.

29,896. VESSELS DRIVEN BY SCREW PROPELLERS. F. G. PRATT, LONDON.

This invention has for its object the arrangement of power and transmission gear so that a maximum of power can be got into a vessel of minimum size whereby a material increase in speed and economy in running results. The propellers are arranged below the keel line, one above the other in echelon. By this arrangement less shafting outside the vessel is presented to the water than if the shafts were arranged in the same horizontal plane. Furthermore, a better distribution of machinery weights is obtained.

2,288. SECURING THE RUDDERS OF SHIPS WHEN DISABLED AT SEA. C. J. W. AGERSKOW. KINGSTON-UPON-HULL, FROM S. FIELDWOOD, CALCUTTA.

At each side of the rudder quadrant two stop blocks are fixed, each being situated so as to allow the necessary normal movement. Each block has a buffer with cushioning spring for absorbing shock when the quadrant comes in contact with it, and also on each block is mounted a catch which projects toward the quadrant. When the rudder becomes uncontrollable from any cause, except breaking, the rudder, swinging beyond the point to which it would move under control, causes the quadrant to strike the buffer and the catch allows the side of the quadrant to pass, but immediately after drops, engages and retains it.